

DOCUMENT RESUME

ED 180 400

HE 012 145

AUTHOR Emery, James C., Ed.
 TITLE The Reality of National Computer Networking for Higher Education. Proceedings of the 1978 EDUCOM Fall Conference. EDUCOM Series in Computing and Telecommunications in Higher Education 3.
 PUB DATE 78
 NOTE 102p.; Proceedings of the EDUCOM Fall Conference (Washington, DC, November 14-16, 1978)
 AVAILABLE FROM EDUCOM, Interuniversity Communications Council, Inc., P.O. Box 364, Rosedale Road, Princeton, NJ 08540
 EDRS PRICE MF01/PC05 Plus Postage.
 DESCRIPTORS *Computers; *Cooperative Programs; Cost Effectiveness; Data Bases; Decentralization; Dial Access Information Systems; *Electronic Data Processing; *Higher Education; *Information Networks; Systems Development; *Time Sharing
 IDENTIFIERS *Interuniversity Communications Council

ABSTRACT

A comprehensive review of the current status, prospects, and problems of computer networking in higher education is presented from the perspectives of both computer users and network suppliers. Several areas of computer use are considered including applications for instruction, research, and administration in colleges and universities. In the opening chapter, William F. Miller discusses the role that computer networking is likely to play in higher education. He notes that a national network often can provide cost-effective specialized services more easily than can individual institutions and is able to offer a wider variety of services than is available at any single computer center. In succeeding chapters, Ronald Segal reports the results of an extensive research project on networking that included the simulation of a national network serving higher education and research. Early experiences of the EDUNET network are discussed by Paul S. Heller, and Robert H. Scott examines important facets of the EDUNET Business Plan. Conference workshops on policy issues in networking, facilitating services for networking, and network resources are discussed by William F. Massy, Tad Pinkerton, and Barry L. Berman in the concluding chapters.
 (Author/SF)

 * Reproductions supplied by EDRS are the best that can be made *
 * from the original document. *

ED180400

The Reality of National Computer Networking for Higher Education

Proceedings of the 1978
EDUCOM Fall Conference

edited by James C. Emery

"PERMISSION TO REPRODUCE THIS
MATERIAL HAS BEEN GRANTED BY

EDUCOM

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRO-
DUCED EXACTLY AS RECEIVED FROM
THE PERSON OR ORGANIZATION ORIGIN-
ATING IT. POINTS OF VIEW OR OPINIONS
STATED DO NOT NECESSARILY REPRESENT
OFFICIAL NATIONAL INSTITUTE OF
EDUCATION POSITION OR POLICY.

EDUCOM Series in Computing and
Telecommunications in Higher Education

3

NE 012 145

Other Titles in This Series

Closing the Gap Between Technology and Application: Proceedings of the 1977 EDUCOM Fall Conference, edited by James C. Emery

Teaching Law with the Computer, Russell W. Burris, Robert E. Keeton, Carolyn P. Landis, and Roger Park

**EDUCOM Series in Computing and
Telecommunications in Higher Education**

James C. Emery, Series Editor

*The Reality of National Computer Networking
for Higher Education:
Proceedings of the 1978 EDUCOM Fall Conference*
edited by James C. Emery

Contributors to this book present a comprehensive view of the current status, prospects, and problems of computer networking in higher education, examining networking from the perspectives of both computer users and network suppliers.

In the opening chapter, William F. Miller discusses the role that computer networking is likely to play in higher education. He notes that a national network often can provide specialized services more cost-effectively than can individual institutions and is able to offer a wider variety of services than is available at any single computer center. In succeeding chapters, Ronald Segal reports the results of an extensive research project on networking that included the simulation of a national network serving higher education and research; Paul Heller describes the early experiences of the EDUNET network; and Robert Scott discusses important facets of the EDUNET Business Plan. In the concluding chapters, William Massy, Tad Pinkerton, and Barry Berman review conference workshops in three broad areas: policy issues in networking, facilitating services for networking, and network resources.

James C. Emery has been president of EDUCOM since 1976. He previously served as director of computing activities at the University of Pennsylvania and as chairman of the Decision Sciences Department of the Wharton School of Business.

Published by Westview Press
5500 Central Avenue, Boulder, Colorado 80301

for

EDUCOM, Interuniversity Communications Council, Inc.
Post Office Box 364, Rosedale Road, Princeton, New Jersey 08540

The Reality of National Computer Networking for Higher Education

**Proceedings of the 1978
EDUCOM Fall Conference**

edited by James C. Emery

**EDUCOM Series in Computing and
Telecommunications in Higher Education**

3

*EDUCOM Series in Computing and
Telecommunications in Higher Education*

All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopy, recording, or any information storage and retrieval system, without permission in writing from the publisher.

Copyright © 1979 by EDUCOM, The Interuniversity Communications Council, Inc.

Published in 1979 in the United States of America by

Westview Press, Inc.
5500 Central Avenue
Boulder, Colorado 80301
Frederick A. Praeger, Publisher

Library of Congress Cataloging in Publication Data
Educom.

The reality of national computer networking for higher education.

(Educom series in computing and telecommunications in higher education; v. 3)

1. Data processing—Universities and colleges—Congresses. I. Title. II. Series: Educom. Educom series in computing and telecommunications in higher education; v. 3.

LB2341.E38 1979
ISBN 0-89158-553-2

378'.0028'54

79-10565

Printed and bound in the United States of America

Contents

Preface, <i>James C. Emery</i>	ix
1. The Role of National Networking in a Changing Computing Environment, <i>William F. Miller</i>	1
The Computing Environment.	1
2. Likely Characteristics of a National Computer Network for Higher Education and Research: Results of a Simulation and Gaming Study, <i>Ronald Segal</i>	9
Introduction.	9
Research Approach	11
The Simulation Model	12
Model Usage	15
Study Results	20
Likely Networking Environment	30
Summary and Conclusion	33
References	35
3. EDUNET: A National Facilitating Computer Service Network for Higher Education and Research, <i>Paul S. Heller</i>	37
EDUNET Services	41
Network Activity	48
The Long-term Perspective	50
4. The EDUNET Business Plan, <i>Robert H. Scott</i>	53
Introduction	53
The Planning Council	53
Context of the EDUNET Business Plan	54

Opportunities	55
Options and Analysis	56
EDUNET Services	57
5. Policy Issues in Networking, <i>William F. Massy</i>	59
University Institutional Policy in a Network Environment	59
Institutional Policy on Networking for Small Colleges	63
The Role of the University Computer Center in a Network	63
Minis and Micros in Hierarchical Arrangements	65
Library Automation in a Network Environment	66
Remote User Support in a Network	66
The Role of the Regional Networks in a National Network	67
Sharing Resources for Instructional Support	68
Authoring Incentives	68
Greater Productivity for CAI and CMI Programs	69
Federal Policy Issues in Computing	70
Conclusion	71
6. Facilitating Services for Networking, <i>Tad Pinkerton</i>	73
Introduction	73
The New Networking Game	74
Generic Versus Specialized Services	74
Commitment to Networking	75
7. Network Resources, <i>Barry L. Berman</i>	77
Financial Planning Models	77
Modeling for the Small College	80
Unusual Machine Architectures	81
Network Simulation	82
CAI Authoring Languages	82
Statistical Packages	83
Social Service Resources	84
Business and Management Resources	85
Health Science and Biological Science CAI	85
Bibliographic and Data Resources	87
Resources for the Analysis of Public Policy	89
EDUNET Resource Use	91

Preface

The Reality of Computer Networking for Higher Education provides readers with a clear picture of the current status of computer networking for higher education. Several areas of computer use are considered, including applications for instruction, research, and administration in colleges and universities. Analyses are presented from the perspective of both user and provider of computer services. These views evolved during the course of a research project in which a university network was simulated, as well as from the early operating experience of EDUCOM's national facilitating network, called EDUNET.

Revised and edited for publication, these papers were originally presented at the EDUCOM Fall Conference in Washington, D.C., November 14-16, 1978. William F. Miller, Provost of Stanford University, served as conference chairman and delivered the keynote address. Ronald Segal, Paul S. Heller, and Robert Scott all participated in the opening plenary session of the conference; William Massy, Tad Pinkerton, and Barry L. Berman summarized much of the workshop discussions in the concluding session of the meeting.

Both the conference and these proceedings provide a forum for the exchange of experience and ideas concerning computer networking. A strong consensus emerged that networking offers attractive new options for higher education. The reality of networking today was demonstrated at the conference in the EDUNET Resource Rally, in which fifteen schools demonstrated computer-based resources available remotely to outside users via EDUNET. A summary of those resources is presented in the chapters by Paul S. Heller and Barry L. Berman.

Readers who wish to obtain more information about EDUNET are invited to telephone network staff on a toll-free hotline: (800) 257-9505.

James C. Emery
President, EDUCOM

The Reality of National Computer Networking for Higher Education

The Role of National Networking in a Changing Computing Environment

William F. Miller

The Computing Environment

It is hardly necessary for me to tell college and university computer-center directors about the rapidly changing computing environment. Recent changes in the types and costs of computing equipment available create new opportunities in the way in which computing can be made available, as well as to whom it can be made available. The increased mechanical, electronic, and software ease of interconnecting devices at all levels simplifies a variety of problems heretofore troublesome in the least. The lower cost of components, including peripheral terminals, personal computers, and the like, makes it possible to put these devices in the hands of people to whom such opportunities would not previously have been accessible. At the same time we need to recognize that introducing computing on this broader scale brings on new problems of coordination, reliability, and security, as well as new economic considerations.

This changing computing environment, coupled with increased attention to financial constraints, provides a substantial stimulation to seek alternative ways to improve computing or reduce costs; that is, to match up new demands with new op-

William Miller is Vice President and Provost at Stanford University. He has been a member of the Policy Board of the EDUCOM Planning Council on Computing in Education and Research since its formation in 1974. Stanford University participates in the prototype version of EDUNET as a supplier of services including data base management services under the SPIRES system for the EDUNET Resources Data Base.

portunities. National networking provides one of the important means for facilitating these match-ups.

I should like to say a few words about increased demands of opportunities for computing as well as increasing financial constraints at universities. From the viewpoint of one who spends a considerable amount of time discussing with other university officers both new opportunities provided by computing and the increasingly more difficult financial constraints, it appears that two forces are at work that are acting against each other. First, there does appear to be an increased interest—demand if you like—for computing in teaching programs as well as in research programs. This is coming about in the social sciences and sciences alike because of the increasing complexity of problems and issues. On the instruction side, this means that more instructors are introducing more complex problems to be solved by computers, and, at the same time, they need stronger computer support in such matters as computer-aided instruction, bibliographic and numerical data bases, report generation, and record keeping. On the research side, the increased sophistication of models, the more elaborate data bases to be examined, and the search for quantification all increase the demands for more computation.

Learning the concept and use of a program or algorithm as opposed to a formula or equation provides a powerful intellectual tool that can be applied to many disciplines and problem areas. This algorithmic approach to problem analysis and problem solving is proving to be as pervasive as mathematics or as chemistry applied to biological problems. Many high school students coming into the colleges and universities have had sufficient introduction to the concept of a program that they are increasingly turning to computing as an aid in problem analysis. We have in no way reached the limit on this type of computer use.

In addition to the increased interest in computing for education and research, there is an increased interest in the use of computing in administration and clerical work. This is brought on by new opportunities that arise through changes in technology and costs, but it is also brought on by increasing demands on administrative and clerical units for greater sophistication

and coordination of record keeping and better analysis of resource utilization.

So the demands are there, yet the financial opportunities are diminishing, not increasing. Some elements of higher education have "faced up" to the increasing financial constraints confronting both public and private institutions. However, many have not, and this is especially true at the departmental levels and operating levels. Let me restate the fundamental economic constraints here.

I shall put the problem in terms of private institutions and tuitions, but you can easily make your own translation to public institutions and taxation. University budgets are largely wage driven. Stanford's operating budget is 85 percent wage driven. About 80 percent of our budget is comprised of salaries and wages, and the services we purchase have wage components amounting to about another 5 percent. If you assume for simplicity's sake that we are either 100 percent wage driven or that increases in costs of the remaining 15 percent are close to the wage rate, then the expense side of our budget will go up at wage rate. That is, the expense side will go up at wage rate *if there is no addition or enhancement of programs*. On the income side, if you assume that tuition must continue to carry the same percentage of budget in the future as in the past, then tuition must go up at wage rate in order to keep a balance between income and expenses. Any additions to program or enhancement of program will drive the expense side, and hence the tuition, at a rate above wage rate. In that case, tuition would take an increasingly larger bite from the family budget. You can easily translate the arguments to the public side.

This next comment is an aside, but one worth making to close the argument. Some individuals argue that the solution for the private sector is to do more fund raising; that is, rely more on philanthropic giving. I have at my disposal a great deal of data on the rates of increase of philanthropic giving to higher education. I do not know of any institution, though, for which the rate of increase of philanthropic giving keeps pace with the rate of growth of expenses over a long term. There are some institutions for which the rate of growth of income from gifts

nearly keeps pace with rate of growth of expenses, but they are just holding their own. Thus, the data do not support the conclusion that we can *increase* the budgetary dependence on gift income. Hence you see the bind.

Now, my reason for mentioning this economic problem is to make it clear that the heroes will be those who are able to introduce new ideas to reduce costs or enhance present programs without the addition of costs. Computing has a great potential to do one or the other of these. However, before rushing out to become the local hero, examine the economics carefully. The conversion costs of some of the projects I have heard proposed are enormous and may outweigh the long-term gains. As an analogy, there are many homeowners who have invested in solar heating systems only to find that in their operating circumstances they will never recover their capital investments. Poor economic analysis of the development and conversion costs of computing can lead to the same result.

National networking provides an opportunity to provide a wider array of services, to gain efficiency in some cases, and to develop a new style of distributing computing. In my 1975 Keynote Address to the EDUCOM Fall Conference, I indicated five general areas in which networking can be an advantage. These areas seem just as promising today, and we have examples of each of them in operation over networks. Let me recapitulate these five areas:

- *Large data bases.* Data bases whose development is expensive and whose storage or maintenance is expensive. Some examples are census and voting data bases, astronomical and astrophysics data, and library card catalogs. These data bases require a great deal of intellectual effort to develop them, expensive data storage equipment to hold them, and continued updating with commensurate maintenance costs.
- *Large special programs.* Good examples of such programs are the large scale modeling or design programs like large weather models or large economic models. These programs are continually being upgraded, and the maintenance effort associated with such programs is large.

- *Large collections or libraries of smaller specialized programs.* The differences between a collection of smaller programs and a single large program may be slight depending on the use. Library automation programs that do card cataloging, book ordering, and in-process accounting illustrate all three of the above qualities.
- *Load balancing and resource shopping and planning.* Via networking a user may find more accessible computing or more economical computing than is available to him or her at home at a particular time. This is an important opportunity that provides for better averaging of use and costs by spreading use over a broader base of equipment. It also provides an opportunity to smooth off peak-load problems or provide capacity during transitions of local equipment changes. This latter capacity can be very significant. Two or more institutions can staircase their equipment changes and provide back-up computing for each other during transitions or emergencies.
- *Exploration of new areas by network.* An institution may wish to use a set of programs on an experimental basis before incurring the cost of transferring or adopting the programs. For example, a given institution may wish to experiment with another institution's computer-aided instruction programs before deciding whether to adopt them and transfer them to a local machine. This is important even for institutions that have sufficient capacity and maintenance ability; it simply recognizes that transfer costs are significant and must be taken into account.
- *Electronic message transfer.* This is an additional networking opportunity whose use we have seen increase. It is especially useful when a number of individuals at different institutions are cooperating on an experiment or even in administrative projects like conference planning or report writing. The rapid turnaround on information is a great enhancement in such cooperative situations.

The 1978 EDUCOM Fall Conference, through its seminars and workshops, displays many examples of these opportunities

for networking. I believe that the membership of the Planning Council who undertook the network studies leading to EDUNET can feel pleased with the results illustrated by these seminars, workshops, and the EDUNET Resource Rally.

However, with these opportunities also come problems. The problems should not be underestimated, nor should they be viewed as insurmountable obstacles. For example, users face problems in evaluating the quality and reliability of a service. It may take a considerable amount of testing and evaluation before a user will make a commitment to rely on another party as a supplier. If an institution has research projects or classes that are dependent on a particular system, the loss of direct control that comes with using another institution's system may constitute a serious concern. Thus, a user may need assurances and a very reliable estimate of a supplier's intentions in the future before committing to a substantial program use of that supplier's system.

There are a number of difficulties entailed in being a user of network services, but I believe there are even larger problems with being a supplier. A particular laboratory or facility at a given institution that has heretofore not been a supplier, may suddenly have to deal with security problems, control problems, accounting problems, and so forth when that facility becomes a network supplier. As long as the supplier is providing only marginal amounts of services, the problems are likely to be small and controllable. I believe that important network sharing can occur on the margin; we should not discount the importance of that opportunity. On the other hand, some major network sharing opportunities will come in areas where the activity could not be considered marginal for a given institution.

An illustrative example that includes many of the problems is library automation. In order to be a good supplier, the provider of library automation services has to be a supplier to many institutions. Somehow or another, the provider must take on the responsibility for the increase in resources needed to be a proper supplier. The question naturally arises as to who will be the banker and guarantor for any increases in resources that are necessary to be more than a marginal supplier. Institutions may

have to be prepared to enter into bilateral or trilateral agreements in order to properly protect and encourage a supplier to acquire additional resources on a large scale.

There are, of course, suppliers on the local and regional level for whom extension to a national network would be a small effort worth perhaps a great advantage to themselves and potential users. Additionally, there are already (and likely there will be more) services that can best be provided at a national level; that is, local or regional user publics are not sufficiently large to support the cost of development and maintenance of the service.

In all of these cases a national network, in particular EDUNET and the EDUNET staff, can and will be a positive force. They can help facilitate agreements, survey the size of potential user publics, and in many ways provide the facilitation necessary to surmount the obstacles of becoming either a user or supplier.

Continuing along these lines, as I have often pointed out before, there is a behavioral aspect to data processing. The network simulation project (see Chapter 2) is one example of a study to increase our understanding of network behavior. In general, a network responds differently than an organization. An organization operates within a set of governance principles, guidelines, and administrative structures, so that policies can be developed to structure the behavioral relationships between elements of the organization and the data processing services. Networks function much more like a market in which opportunities, incentives, disincentives, and the like play a far bigger role than structured policy decisions. Awareness and forethought about some of these behavioral problems can lead to smoother interactions and uncrossed obligations within networks.

Again, EDUNET and the EDUNET staff will collect and study data that should shed light on behavioral responses and provide guidance for institutions in their policy making. It will be especially important to have this particular kind of talent to assist on such problems.

Stanford University is committed to being a sustaining member of EDUNET. We join this effort being fully conscious that the membership fee does not constitute the full cost of being a

sustaining member, in particular of being a supplier. There may be institutions for which there will be few additional costs. Furthermore, management and local service costs may go down over time as formats, protocols, and the like become standardized.

In spite of that recognition, we believe the services that we will get from the EDUNET staff for facilitation and analysis will be well worth the cost of membership. At Stanford, we continually engage in "make or buy" decisions. Here is a case where we intend to buy instead of trying to carry out those analyses and facilitations ourselves.

Finally, Stanford is committed to EDUNET purely for academic reasons. We do not see any purely economic gains by joining EDUNET; we are not in the business of selling services for economic reasons. We do believe that we can provide the faculty, students, and staff of our institution with a considerable enhancement of their computing capabilities by making EDUNET available and, moreover, we believe that we must and should reciprocate by making available any services which others may seek from us.

It is in this spirit and with this understanding that we join EDUNET, and I hope many others will join us.

Likely Characteristics of a National Computer Network for Higher Education and Research: Results of a Simulation and Gaming Study

Ronald Segal

Introduction

The difficulties involved in finding a cost-effective way to satisfy the expanding and increasingly varied demands for computing services in higher education and research are generally recognized.¹ Similarly, the potential attractiveness of national networking as a means for satisfying many of these demands has been often expressed.^{2,3,4,5} In fact, a series of working seminars sponsored by the National Science Foundation in 1972 and 1973⁶ led to two major efforts to further examine and realize this potential. Development of a prototype facilitating network, EDUNET, was begun by the Planning Council on Computing in Higher Education and Research.⁷ This development is described fully by Paul S. Heller in Chapter 3. In parallel with EDUNET developmental work, participants in the Network Simulation Project conducted a broad investigation of the elements critical to network success or failure, and the likely impact of such a network on institutional participants.^{8,9}

Recognizing that for some time it has been technically feasible to create a national network of computer facilities at colleges, universities, and research institutions, General Working Seminar participants viewed the primary difficulties confronting such a network as nontechnical. In particular, economic, politi-

This work was sponsored by the National Science Foundation under Grant Number MCS75-03634, "A Simulation and Gaming Project for Inter-Institutional Computer Networking" (Network Simulation Project).

cal, and organizational factors were considered likely to pace the development of a successful network. In order to deal with these issues, seminar participants recommended that a clear understanding of the potentials, limitations, and implications of networking be developed. The objective of the Network Simulation Project, therefore, was to obtain that understanding.

While the Planning Council undertook a very pragmatic and focused developmental approach, obtaining operational experience, the Network Simulation Project was less constrained and looked at longer-term implications, explored a greater variety of networking approaches and alternatives, and, in particular, considered many of the complex behavioral, political, and organizational issues. The combination of the depth and focus of the Planning Council and the breadth of the Network Simulation Project has been a very powerful and complementary relationship. Although the simulation project had a research mission, it also critically needed the practical insights and experience that EDUNET could provide. Similarly, the research results were vital to the operational decisions of EDUNET. Rarely has a research endeavor been so critical to the needs of an operational activity and vice-versa. In fact, most of the important results of the Network Simulation Project were incorporated into the EDUNET Business Plan before the final project report was completed.

The project was administered by EDUCOM, with the active participation of eighteen educational and research institutions.¹⁰ Participating institutions provided data for the simulation model and research analyses, reviewed and reacted to materials, and were the primary users of the simulation model. Collectively they represented a possible network in which services could be exchanged in a market mechanism. These institutions were:

Bryn Mawr College
Carnegie-Mellon University
University of Chicago
Dartmouth College
University of Georgia
Harvard University

National Bureau of Economic
Research
Ohio State University
University of Pennsylvania
St. Olaf College
Stanford Research Institute

University of Iowa

Lehigh University

Massachusetts Institute of
Technology

Stanford University

Texas Tech University

University of Texas

Vassar College

Research Approach

While existing computer networks provide an indication of the costs and technical characteristics that might be associated with a national network, they cannot indicate how member institutions would be affected by the availability of multiple resources at a variety of prices, how "balance of payments" problems (both deficits and surpluses) would affect institutions, and how a network might be affected by institutional actions. These are critical issues, and past experience provides little insight for dealing with them. These questions can best be examined in an environment in which the implications of policy alternatives can be observed in concrete terms. Moreover, that environment should be free from constraint by *a priori* solutions, so that aspects of network management and control can be subject to experiment and change.

No existing network has the necessary characteristics to permit the study of these issues. Although the ARPA (Advanced Research Projects Agency of the Department of Defense) network, for example, offers interconnection between computing facilities at many universities and research institutions throughout the country, the single-source nature of the funding for most of the computing activities removes the cause of many of the problems that need to be investigated. The use of a real network to examine many of these issues poses a number of additional problems. Experimentation on a national basis would be extremely costly, would take several years to conduct, and would be severely restrictive in the approaches and alternatives that could be investigated. It would also be disruptive to the normal operations of both the network and its institutions, and it would require an inordinate commitment of energy and time from key individuals across the country.

In recognition of these difficulties, a simulation approach was selected to investigate some of the behavioral and policy

issues of a national computing network for higher education. The simulation approach provided flexibility in the types of networking situations that could be examined, and allowed for the testing of a variety of alternatives at a relatively low cost.

Although the simulation approach was a unique part of the project, it was not the only area of research activity. Most of the research relied on more traditional data collection, analyses, and tests. For example, there were several major data collection efforts. Three rounds of written questionnaires emphasized organizational and operational profiles of the participating institutions; historical data describing hardware, software, usage, budgets, and financing; and policy and behavioral characteristics. Detailed benchmark tests of computer facilities compared prices and performance at many institutions. Finally, in-depth interviews of key personnel were conducted at each site.

In regard to these activities, the close relationship with the EDUNET design and implementation process must be mentioned again. Much useful data was obtained from EDUNET, especially data on what individuals and institutions were willing to do (or not to do) when asked to make formal commitments of resources.

The Simulation Model

Design Goal

The basic design goal¹¹ of the simulation effort was to provide a highly parameterized and flexible model that would permit the examination of a variety of institutional and network policies and profiles. The model, in conjunction with data representing the computing requirements, resources, policies, and facilities of the individual institutions, could then be used to explore a variety of possible network implementations, management structures, usage models, and growth patterns.

In the model, all policies were represented as subroutines called up whenever a policy decision or policy-influenced action was required. Users of the model could therefore describe their sites' practices parametrically by selecting routines from a stored policy library. Considerable flexibility was thus available

in representing a given institution, and it was relatively easy to modify or expand the internal policy library as required.

Model Structure

The simulation model was designed to handle up to twenty sites. In addition to the representation of each site's hardware, software, and use of computing services, the description of each site contained all necessary policy specifications and decision rules. The decision rules dealt with such areas as pricing, support levels, computer scheduling, and priority-setting.

The simulation model has three basic conceptual elements: service offerings, user requirements, and the balancing of user demand with available supply in light of network facilities and constraints. Each site on the network was viewed as having specified service offerings, and available capacity measured in such terms as processor time, primary memory size, line printing potential, and communications bandwidth.

The demand for, and supply of, computing resources at each site was expressed in terms of computing categories called "service types." Each service type was presumed to include a reasonably homogeneous type of work. While the present twenty-five service types represent an over-simplification of the workload, they are sufficient to adequately represent the supply and demand of network resources. More service types could have been added, but model memory requirements would have been unnecessarily increased.¹²

The model operated with a basic time unit of one week. Although the week-long time increment precluded use of the model for investigating hour-by-hour variations in the processing loads at individual facilities, it did not preclude the examination of service characteristics having time aspects of less than one week. The weekly time interval was selected because it was small enough to reflect overall network dynamics, large enough to be computationally feasible, and compatible with typical weekly, monthly, quarterly, and annual decision cycles.

The model was programmed in FORTRAN IV and implemented in a top-down structured manner. The full system

presently consists of about 35,000 lines of code and runs in 700,000 bytes of memory. The system includes the simulation model, a series of data files describing the network institutions, and an interactive user interface. The interface is used to update the data files, to define the network configuration, and to describe simulation runs and the output reports and other data from the runs.¹³ Output reports can also be produced off-line on a high-speed printer. (For more detail on model objectives, design, and usage, see references 14 through 16.)

Institutional Representations

Within the simulation model, representations of each of the participating institutions contain algorithms for predicting what happens at that site. These algorithms simulate a variety of site characteristics:

- administrative, management, and financial aspects of computing;
- available computing resources;
- nature and magnitude of demand for computing services by various categories of users;
- policies and procedures for allocating computing resources; and
- policies for defining possible network participation.

To a significant degree, the site models can be used to explore the implications of alternative financial, technical, and policy options within the site, independent of the larger networking context. In addition, policy and behavioral data describe the permissible and likely interactions of the institution with a network organization.

Network Representations

A network, as defined for simulation purposes, is viewed as a collection of sites (or institutions) capable of sharing computer resources under a specified set of conditions. The model predicts the interrelationships among these sites in terms of the flow of services, the flow of funds, and the interactions between

institutions. To accomplish this, it is necessary to simulate what happens within each institution as well as what happens among institutions.

The organization of the particular network to be simulated can be varied in several ways. The most obvious variation is in the number of sites and their characteristics; for example, large or small, public or private institutions. Other network descriptors that can be explored include communications costs and capacities, financing of the network organization, and constraints on work flow.

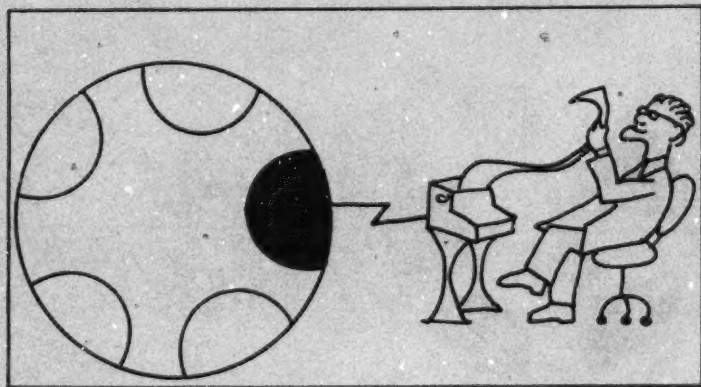
Model Usage

Single Site Network

Three major applications of the model were carried out. In the "single site" usage (Figure 1), only one site was considered at a time—typically a representation of the current computing situation at a participant's institution. The primary purposes of this phase were to provide user training and familiarity with the model, and to have the users validate their individual site representations.

Several institutions were able to carry this phase further and use the model as a tool for planning and exploring such areas as internal pricing policies, capacity adjustments, hardware utiliza-

Figure 1. Single Site Model Usage



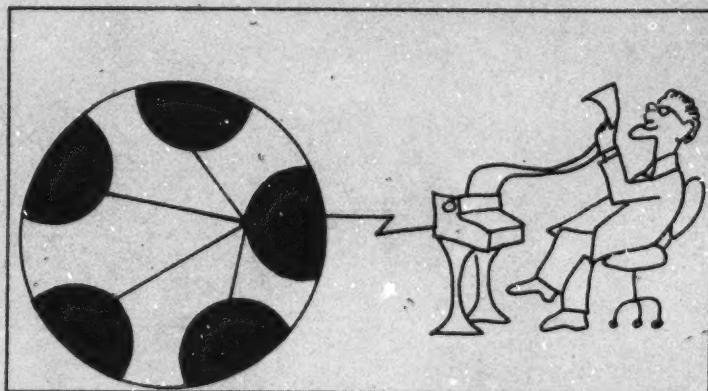
tion, and funding mechanisms. For example, the computer center director could look at the simulated effects on service of adding more interactive terminals, modifying software offerings, or upgrading the central processor. Since service pricing and other financial parameters are included in the data for each site, the single site model was used at a few sites to analyze the effects of changes in prices or cost-recovery policies.

Straw Network

The model was next used as a "straw network" (Figure 2) in which multiple sites were included, but only one site could modify its policies or behavior during a run. If work flow is permitted among sites, various relationships between the subject site and the hypothetical static network can be explored. This provided a simulated network for individual sites to look at alternative modes of network participation. Any one site could therefore explore a variety of policies and decisions vis-à-vis an outside network. For example, a site could study the effects of external purchases of computing by allowing its local users various levels and types of access to network resources. An institution could also explore the consequences of alternative policies regarding the sale of its own computing services to other users on the network.

In addition to the above usage, the straw model was the

Figure 2. Straw Network Model Usage



focal point of staff examinations of network-wide policies and options. The examinations were performed by fixing (or pre-setting) all site policies and varying the parameters that describe the network organization. Some of the areas studied in this project phase were:

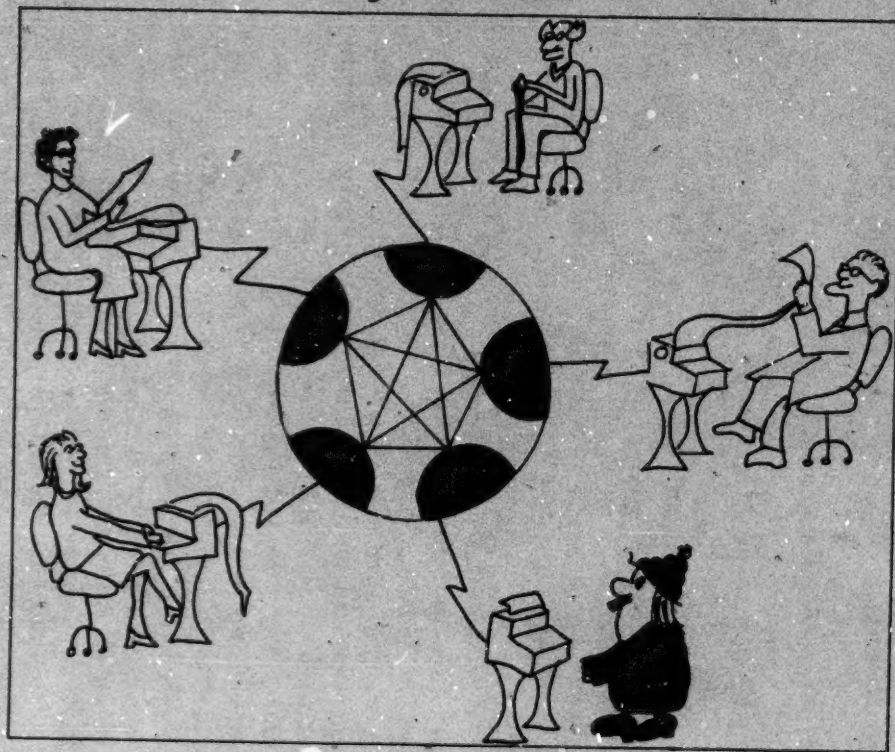
Network organization and management	Quality of network information
Network composition	Quality of network services
Site specialization	Pricing policies
Communication costs	Impact on institutional computing
Network stability	Economic impact on institutions
Modes of participation	Provision of special services
Network growth and evolution	

Live Game

Although the straw network usage of the model was extremely useful for participating institutions and staff research, it was recognized that no simulation model could completely encompass the many possible behavior patterns that might occur in the real world. The only way to observe the dynamic, competitive aspects of networking was to include real decision makers in the simulation. Thus, in addition to the technical studies, which required no human interaction, the simulation model was used in a gaming mode to investigate situations in which institutional behaviors, policies, and interactions were important. In the gaming environment, the policy and behavioral portions of the model were controlled by real decision makers, who reflected the many diverse sources of influence affecting computing in their respective organizations.

The three-day gaming exercise,^{17,18} referred to as the "Live Game" (Figure 3), involved sixteen institutional teams who made decisions about their likely participation in a network that "progressed" through several years of simulated time. Each institutional team consisted of a senior administrator, the computer center director, and a representative of the institution's user community.

Figure 3. Full Game



Since real decision makers can provide the only mechanism for reflecting the full richness and complexity of institutional behavior in a networking environment, the live game represented a focal point in the conduct of the project. Participants made decisions similar to those they would make in real life; decisions that reflected the full complexity of the many influencing factors. The simulation model was used to help integrate the data and the decisions, and to reflect the impact of decisions on network participation and operation.

Typical decisions faced by institutions in the gaming exercise concerned the general management of computing at the institution, financing the provision of computer services for both internal and external users, and paying for the use of external services. Other decisions concerned the organization and financing of a network facilitating organization and rules and regulations governing network trade. It is interesting to note that, unlike most gaming exercises, the participants represented their own real-life roles and made decisions with full awareness of the motivations and constraints existing at their home institutions.

The intensive three-day sessions were realistic enough¹⁸ that participants were "seduced by the game," as one observer noted, and reacted as if the simulated situations were real. The dynamic development of the network allowed them to experiment with alternate network participation profiles and to investigate the impact of particular choices. In addition, the institutional teams were able to discuss a number of side issues among themselves and with their counterparts at other institutions.

In parallel with the investigations of institutional involvement, an examination of the role of a network facilitating organization provided information about the services such an organization might offer and the ways in which it might be supported. This was accomplished by adding a network organization and staff, SIMUNET, to the gaming environment. Reacting to the needs of individual institutions, and to the directives of the network board of directors (composed of the senior administrators of the participating institutions), SIMUNET dealt with such issues as network organization and management, network

composition, financing, network service offerings, site specialization, and network growth and evolution. This activity proved to be directly useful in the development of the EDUNET business plan, which is described by Robert Scott in Chapter 4.

The live game provided the participating institutions with a unique opportunity to explore many of the key organizational, economic, and behavioral issues involved in networking. Although most of these issues had been identified through the course of the project, they had never been presented in terms of the specific decisions that must be made at each individual institution and the impact of those decisions on the institution. In addition to exploring decision making and policy formulation in a networking context, the participants were able to examine some operational aspects of network participation and the possible impact that a network might have on their own computing facility. In both these areas, the live game represented a learning experience that could not be easily duplicated. The experience should be extremely useful as new opportunities for participation in a real network become available.

Study Results

Positive Indicators for Networking

Analyses of the resource and policy data collected from the participating institutions, investigations using the simulation model, and experiences at the live game have revealed a variety of positive factors associated with a national network. Several of them are summarized here.

Operational economies. The availability of network computing resources can lead to the combining of facilities, a reduction in size or range of offerings at some computer centers, and better utilization of the remaining facilities. Any of these alternatives can result in operational economies. For example, Harvard has been able to significantly reduce the size of its central computer facility by relying heavily on remote services. At the same time, Harvard's primary supplier, MIT, was able to justify an expanded and better staffed operation because of the guaranteed outside

usage (income) from Harvard. The cooperative arrangement results in a more powerful and cost-effective service to the MIT community. Obviously, a national network will not enable everyone to participate in this manner. However, the opportunity is there for institutions in appropriate circumstances.

Complex software and data base economies of scale. An often expressed hypothesis is that most computer facilities devote 80 percent of their development and maintenance resources to 20 percent of their applications. Frequently this ratio is given as high as 90 to 10, or more. The exact ratio isn't important. What is important is that overall costs could be lowered significantly if some of the inefficient applications could be satisfied externally. For a variety of services, development, maintenance, and user service costs do not vary significantly with usage. Since a centralized computer center can spread these costs over a larger number of users, it can provide substantial economies. As hardware costs continue to decline and software-related costs continue to increase, economies achieved by spreading costs over a large number of users will become increasingly important.

Availability of specialized services. One of the great advantages of a network is that it allows specialization while still exploiting economies of scale. A computer center that offers a specialized service, whether it be in the hardware, software, or data base area, can attract enough network users to justify the high fixed costs of developing the service. Thus, the availability of such services is likely to increase rapidly as networks complement localized centers. A computer center can choose to provide relatively standard services for its own users, plus a few specialized services for the national market. It can then look to the network to obtain additional specialized services. Data collected by the project indicate that a wide variety of specialized services appropriate for a network environment are already available. However, it is likely that these services represent only a small fraction of the total that would be developed once the potential usage base was realized.

Economies of comparative hardware advantage. Not every computer system can process every type of job with the same

relative efficiency. Hardware and operating system design differences, as well as local modifications to computer systems, have resulted in a wide variety of configurations, each having different processing characteristics and capabilities. As a consequence, systems have different relative advantages. If one were to take the processing that is being performed at a set of institutions, and redistribute it among these same institutions on the basis of the comparative advantage of their computer systems, net computer resource usage would decrease relative to capacity.

A series of benchmark programs developed in conjunction with the Planning Council illustrate the point dramatically.¹⁹ Although subject to all the usual problems of representativeness, the benchmark programs have been run at over thirty institutions. They provide a system-by-system comparison of the difficulty of converting a program from one site to another and the computer resources and costs required to execute different programs. In the tests, price differences on the order of 10:1 and even 20:1 occurred for the processing of a given job. Although the lowest-priced facility is not always the most effective when all factors are considered, price differences are often attractive enough to encourage individual users to take advantage of the comparative advantages of different systems. Major economies could result. Admittedly, prices are not always directly tied to costs,²⁰ and many of the price differentials would diminish in a free market environment. However, the institutions involved believe that their pricing was an accurate reflection of true costs at their facilities and that substantial changes would be unlikely.

The identities of the "lowest cost" and "highest cost" institutions were not constant across the benchmark jobs. That is, one institution was more efficient for some job classes than for others. Since the trading opportunities are not one-sided, there should be a reasonable distribution of usage. This situation is analogous to the economies of comparative advantage in international trade²¹ and should result in similar distributions.

National software marketplace. At present there is no simple marketing or distribution mechanism for available software. To market a product, developers must first prepare user documen-

tation and installation instructions. Next, they must prepare different versions for different computer systems and must be prepared to consult on implementation problems. Finally, they must develop and distribute periodic maintenance updates for all systems. For the person who is not in the business of software development, these requirements form a significant barrier. Consequently, most local developments are not exported, and duplicate development is necessary if the capability is to be obtained at all. The existence of EDUNET will change much of this, since prospective users will be able to use software on the developer's own system. Since all users can run the same program on the same system, only one set of documentation and one maintenance operation is required. The burden is greatly reduced for the developers, who are usually more interested in their disciplines or research subjects than in software development and marketing. Also, in a national software market, usage royalties can provide an economic incentive to develop and support good software, and can provide a mechanism to support the costs of polished documentation and user support. Thus, the network framework could support greater sharing of software development costs and a faster spread of beneficial software.

Internal management improvements. Although computing has grown into a substantial business at many institutions, the effectiveness of the management and operation of the local computer center has not always developed at the same pace. In all too many instances, project data and on-site interviews revealed that large computing facilities are still being run as if they were small service facilities. Although most of these large computer centers developed rapidly over a very few years, they are now large businesses and should be recognized and operated as such. The existence of a national network would bring a measure of comparison and competition to all participating institutions and provide implicit standards. This was dramatically illustrated at the live game. Not only did prospective users make price comparisons, they also compared service, support, and reliability of supplier centers. When local college administrations permitted users a free choice of computing facilities, poorly managed facilities found themselves in a weak competitive

position and were forced to upgrade operations, artificially restrict local users from taking advantage of the network, or lose business to the better-run facilities. From the viewpoint of many individual facilities, this was a traumatic experience. Admittedly, in a real network environment it is unlikely that many users will be free to do their computing off-campus or that they would be very mobile even if they were free to go elsewhere. However, the visibility of a network will still accomplish most of the desired results, and users will realize more effective service.

Positive attitudes. A positive attitude is critical to the success of any endeavor. Surveys of regional networks in higher education^{22,23} showed that many networks succeeded or failed in large part because of the beliefs of key participants that the network would succeed or fail. In the case of EDUNET, our interviews with administrators, computer center directors, and others revealed a consensus of positive attitudes, at least among those likely to participate in the early phases of the network. Administrators envisioned increased research potential, better overall service to their user community, and, possibly, some cost savings. Realistically, few were counting on major early cost savings. Computer center personnel anticipated a wider audience for their offerings, greater service to internal users, and elimination of some costly local services. Users felt that "competition" would eventually bring more cost-effective service to them, and that the expanded availability of suppliers and offerings would be beneficial. Although such attitudes do not guarantee the success of a networking activity, they are a vital ingredient in achieving success.

General network stability. In addition to the live game, a number of explorations were conducted using the simulation model.^{9,15} In these tests, perceived decision and behavior patterns of all sites were preprogrammed, as compared to the live game, in which real people made the decisions at each site. Although the results were not comprehensive and must be viewed as indicative rather than conclusive, indications were consistently positive in all areas tested. The network appeared stable in the face of large shocks, there was opportunity for

large cost savings to users, and communications costs were relatively low for many of the likely early usage categories. The more attractive supplier sites seemed to have sufficient available capacity, and the different hardware configurations appeared to present useful differences in performance features.

Barriers to Networking

Project analyses revealed a number of potential barriers to networking. Although adverse, these barriers are not insurmountable. However, they must be addressed by EDUNET or any other network.

Institutions are unprepared for a network environment. Many institutions view the network as a mechanism for selling "a little" excess capacity to obtain "a little" extra revenue. They are not prepared to serve the growing computing requirements of a national user community. That is, most institutions, even if they possess a highly desired set of services, would be very unlikely to install additional computing equipment or expand staff solely to serve the needs of network users. In many cases, the charter of the institution or the laws and policies under which it operates preclude such expansion. On the other hand, most institutions believe (in many cases, quite strongly) that they must have a major central facility on site if they are to maintain their position in the research and teaching communities. Further, few institutions have a great deal of short-term flexibility to reduce their scale of computer operations, even if they deemed it advisable. Fixed investments in purchased equipment, long-term leases, personnel commitments, and state restrictions all serve to make rapid change difficult. Thus, we have a situation in which facilities are unlikely to be expanded or contracted significantly. This implies that the imports and exports of computer services at a site must either be fairly closely matched, or must be small in magnitude relative to the total computing budget. Although it is possible that many individual sites will ultimately make dramatic changes in the amount of computing done locally, it must be assumed that this will not be the case in general. Even the most optimistic prognosticators are estimating that the long term potential for

EDUNET is less than 5 to 10 percent of all educational computing. In the short term, it is likely to be far lower than this.

Lack of incentives for sharing. Network computing growth is likely to be constrained by the lack of strong incentives to encourage sharing. Incentives to share are missing for both the buyer and the seller of services, at the individual and institutional levels. On the buying side, individual users are likely to be frustrated by shortcomings in documentation, consulting, and other support services; by the unreliability of existing software and data bases; and by difficulties in locating and gaining access to appropriate remote resources. (EDUNET is actively addressing the latter problem.) At the institutional level, money spent on remote services by internal constituents is usually perceived as "real" money, resulting in a financial drain on the institution; the cost of local services is largely fixed and does not impose significant incremental costs in the short run if usage is increased (nor incremental savings if it is reduced). Consequently, there is often a reluctance to permit access to outside services.

Unfortunately, the situation is just as difficult on the supplying side. Faculty members and other individuals who create programs and data bases typically receive neither financial benefit, nor the kind of professional rewards associated with the publication of a paper in a prestige journal. Consequently, there is little incentive to undertake the incremental work required to document, remove errors, and otherwise convert a successful "local" resource into one that is acceptable for a network environment. Institutions also lack strong incentives to become suppliers. Economies of scale in computer hardware have traditionally been one of the primary justifications for concentrating a variety of computing functions into a single large central processor. However, except for a few quite specialized cases, hardware economies are no longer an important motivation. Minicomputers now compete economically with the large machines for raw cycles, and any significant economies of scale for very large jobs can usually be obtained regionally, if not locally. Further, the cost of the central processor relative to total computing costs is shrinking rapidly. Most institutions,

therefore, have little to gain from trying to use network demand to justify a larger central processor. However, economies of scale still hold for large, specialized processors in such fields as physics and meteorology. Thus, for example, the ILLIAC IV computer at NASA Ames is likely to become a major network resource.

Unfair competition. Not all institutions that might belong to the network operate under the same regulations. For example, most educational and non-profit research institutions performing government-funded research are bound to operate all services on a fully cost-recovered basis. On the other hand, government laboratories often acquire computing equipment with capital funds that do not appear in their cost base. Thus, they can and do offer services to other users at marginal or operational cost. Further, commercial organizations could offer services via the same or a compatible network. Loss leaders and other types of promotional prices could be established. Thus, institutions committed to a large central facility could find their user base severely eroded by price competition, their ability to compete on price severely restricted, and their ability to reduce expenses limited.

Guarantees. Institutions that might potentially offer computer services over a national network have shown little willingness to provide long-term service guarantees to outside users, except in some very special cases. Their basic operating policy is "our users first" (and properly so, according to their charters). Thus, if demand were to exceed available capacity, the needs of local users would be considered first, and other institutions and users could not depend upon an equal consideration of their needs. Although it is unlikely that abrupt large-scale cut-offs would ever occur, the possibility of diminished focus is a significant concern. Looking at the problem the other way, most users are not in a position to make long-term usage commitments. However, without such commitments, most supplier installations would be unwilling to assume the risks inherent in expanding capacity or services.

Usage barriers. Although service and price (economics) are powerful motivators that encourage users to shop for and switch

to outside services, user behavior profiles developed at each institution confirm that current computing technology limitations still pose significant barriers. First, there are differences from site to site in command languages, file procedures, and accounting methods. Even such things as "standard" FORTRAN compilers have differences and unique "quirks." Learning to work with many different sites is such a burden for most users that only a small number of them are even potential network customers. Second, software conversion is time-consuming and unrewarding. Once a supplier site is selected, software will likely be developed and executed at that site for the duration of its useful life. Evidence indicates that even sharp differences in price or service levels are unlikely to cause any appreciable shifting of existing programs between sites. A third barrier is lack of information. Users need to find out what is offered where, how the systems operate, what the pricing structures are, and so forth. Further, they need a mechanism for determining how effective each site is for their own computing needs. Unless this fairly costly process can be written off over a significant amount of future computing, it is not cost-effective to consider many other supplier sites. EDUNET plans to play a major role in providing this kind of information. It remains to be seen, however, whether EDUNET facilitating services will be adequate to overcome all of the listed barriers.

Network overhead. Participation in a network is not without cost. In addition to the cost of communications between sites, interfaces to communications facilities have to be implemented for each host computer; billing and accounting routines have to be modified so that information can be provided directly to each user, institution, or network clearinghouse; administrative structures must be implemented; and the network operation must be supported. In the case of EDUNET, the cost of participating as a "supplier" is large enough to deter institutions that only want to distribute a small volume of services.

Security. Many administrators believe that current systems provide inadequate protection against malicious or unintentional access to system resources. Until this situation is corrected, most institutions will choose not to maintain sensitive

data on remote storage devices accessible through a network. Applications involving personnel or student records, detailed financial data, or other confidential information will thus be unlikely candidates for early network service. Another aspect of security is protection against unauthorized use of network resources. When an institution provides its own computing services to campus users, its total financial risk is limited to the expense of running the computer center, which is usually a fixed cost. In the case of a network, however, an institution's potential consumption of resources could be virtually unlimited, and financial liability becomes a serious concern.

Government, regulatory, and tax issues. A number of unresolved legal and regulatory issues must be faced. For example, can a nonprofit educational institution freely sell computing services and still retain its nonprofit status? How will the requirement that the federal government must receive the most favorable price offered to any buyer affect the ability of institutions to use flexible prices in rationing their resources more efficiently? Will state legislation requiring both the sale and purchase of computing resources at state universities to be limited to in-state facilities exclude these institutions from national network participation?

Because of educational discounts associated with equipment acquisitions, institutional charters, or tax regulations, many institutions are unable to process computing jobs for particular types of clients. Commercial work, for example, is prohibited or severely limited at many sites. Although an institution can exercise some degree of control over its own local users (i.e., forbid commercial accounts), it is very difficult to exercise such control over unknown network users. Thus, a commercial user that cannot use the low-cost service at institution X, might be able to obtain system entry at less restrictive institution Y and hence be able to access institution X as a Y-user. This is a serious concern to some institutions.

Unfulfilled expectations. As mentioned earlier, many people, including numerous administrators and computer center directors, have very favorable attitudes toward networking. However, there will be many disappointments because of inappropriate

expectations. For example, project data show that most institutions believe that they offer attractive, economical services and that, in a free market environment, they would be net sellers to the network. It is not fruitful to critique the individual viewpoints, but it is obvious that not all institutions can be net sellers. This point was made painfully evident during the live game exercise. In the regional networking programs undertaken in the late 1960s,²³ such disappointments often resulted in changes in attitudes and the erection of artificial barriers to trade that adversely affected the networking endeavor.

Likely Networking Environment

During the course of the research, a number of likely characteristics of a national network emerged. For obvious reasons, many of the points made below are fully compatible with EDUNET developments and the EDUNET business plan discussed in the next two chapters of this volume.

Network Organization

Hierarchy of computing alternatives. It is likely that a variety of computing alternatives will be made available to users, each serving a different need. The alternatives might include personal computers, local micro- and minicomputers, campus centers, campus networks, regional and state networks, national networks, and commercial facilities. Each of these will play a role and, in general, the roles will be complementary.

Autonomy of members. Colleges and universities in the U.S. are largely autonomous, and they show no intention of relinquishing this autonomy in their quest for computing efficiency or power. This strongly suggests that a successful national network for higher education must be largely decentralized. Within EDUNET, for example, each institution will be allowed to choose which services it will buy, which services it will sell, and to whom it will sell them. Institutions will also be free to determine the prices, the level of support, the availability, and the quality of services they will provide to others. Similarly, they will purchase only those network services that they consider worthwhile.

Central facilitating function. Although decision making is likely to be largely decentralized, certain facilitating functions need to be provided centrally. Included in such functions are billing mechanisms; information on services, prices, and standards; and the provision of network-wide user services. (These are the services described in the EDUNET business plan.)

Financially self-supporting. A national network of autonomous members must be self-supporting and will likely rely on a free market mechanism to provide incentives for both suppliers and buyers. Although financial assistance from government agencies and private foundations might be available to accelerate the development process, the operational network must be economically viable on its own without subsidy.

Evolution of successful suppliers. The data collected to date indicate that some of the most popular sites will "spin-off" their computing facilities (or at least that portion which serves external customers) to a separate not-for-profit, or even for-profit, subsidiary. Under such a scenario, many universities and research institutes would reduce their own local computing capabilities and either use or provide service from a "computer service business." Consequently, what started as a network linking the computer facilities of a number of research and educational institutions, might well turn into a network including a number of university-owned service bureaus. Several examples of such evolutions already exist. The best known are the Dartmouth Time Sharing System (DTSS), the Ohio College Library Center (OCLC), and the Stanford Library System (BALLOTS).

Network Development

Usage growth. Network usage is likely to increase at a steady rate, without any sudden surges in growth. A relatively long transition period is expected while buyers gain experience with network services and institutions adjust their internal capacities to conform with changes in demand patterns. Suppliers will use the transition period to develop more powerful aids for assisting remote users, while the network operations fully develop their facilitation capabilities.

Evolution. The network structure is likely to evolve gradually, rather than emerge in one major step. The formal inauguration

of EDUNET on July 1, 1979, for example, represented a change in governance and financial structure, but brought little change in usage or activity. In order to facilitate adaptation to changing needs and technology, at each stage of implementation the design will need to be kept as open-ended as possible and should avoid large fixed costs (e.g., costs should be incurred in proportion to the level of network activity).

Volume of usage. There will be a wide variance in network activity among participants, with individual site usage ranging from minimal to total dependence. The most optimistic present estimates suggest that network dollar volume will never represent more than 5 percent of the total computing done by member institutions. Note, however, that even at very low per-unit levels, aggregate flows from all members could ultimately be very large.

Initial financing. The goal of financial self-support described earlier implies that ultimately network income will primarily depend upon a combination of user surcharges and supplier payments proportional to usage. There may also be a charge to cover the fixed cost of supporting the individual or organization as a network member. Unfortunately, it is clear that early network volume will be too low for this scheme to provide sufficient income, and additional funds will have to be provided. EDUNET, therefore, is taking the approach that network member institutions will find it in their long-term self-interest to support the network initially with annual fixed dues payments that are high relative to the short-term benefits received. As usage and membership grows, the surcharges and supplier payments will represent a larger percentage of operational income relative to the fixed charges.

Network Usage Modes

Functionally distributed. Within the hierarchy of computing options described earlier, economics favor local or regional computing for most services, with the national network providing services that cannot be economically supplied or maintained on a local or regional basis. Most suppliers will therefore concentrate on a relatively few functions that exploit their comparative advantage.

Specialized services. The specific specialized services that are likely to exist in a network environment are difficult to predict in advance, although communications constraints are currently forcing an emphasis on services with low to medium volumes of data transfer. Probable specialized services will be those requiring some combination of complex software, large data bases, sophisticated support, and specialized facilities. Examples include library services, bibliographic services, person-to-person communications through "electronic mail," chemistry and census data bases, econometric forecasting systems, and high energy physics computations.

User Support

One of the barriers to network usage mentioned earlier was the difficulty of appropriately supporting remote users. In addition to all of the traditional forms of user services currently provided, any national network will most likely offer some combination of the following as well:

- On-line information data bases to assist users in locating remote services appropriate to their needs.
- Local and central consultants who are knowledgeable about services available over the network, or who can at least facilitate the acquisition of information.
- "Circuit riders" who periodically visit network sites or user groups.
- Remote consulting services provided on-line over a "hot-line" or by means of an "electronic mailbox."
- High quality documentation designed to serve the independent remote user.
- Computer-assisted on-line training aids.

Most of these new support services can best be provided by the central network facilitating organization.

Summary and Conclusions

Network Simulation Project studies support the expectation that the establishment of a national resource-sharing computing

network for higher education and science research is a formidable task. The barriers described in this chapter will not be easily overcome. However, all evidence points to a potential high payoff from, if not a vital requirement for, such a network. In particular, the specialized hardware and software resources that would be made accessible could not be made broadly available by any other mechanism.

Establishing computer-based resource sharing at the national level is no longer an issue; formal networks already exist, and many other institutions are supplying services to a national audience by simply connecting their hardware to common carriers like Telenet or TYMNET. However, the exact form of a coordinated national network and the amount and type of activity that will take place are still open to discussion.

The studies conducted as part of the Network Simulation Project indicate that a network organization should emphasize its role as a facilitating agent serving both suppliers and users. Capital investment should be minimized, and costs should be related to usage or value. It is important that charges reflect costs in such a way as to permit the network to be financially self-supporting in the long term.

The business plan for EDUNET is formulated to be consistent with these principles. However, in recognition of expected slow initial growth, income during the early years will need to be based more on user and supplier membership fees than on usage surcharges or royalties. As usage grows, this emphasis is likely to be adjusted.

Early indications are that the current environment is extremely favorable for national networking. Both potential suppliers and users see it in their self-interest to participate in networking activities. Attitudes toward networking are positive and constructive, and administrators at the highest level are becoming actively involved. If short-term pay-offs from network participation can be made attractive enough to sustain interest during the difficult development period, the prognosis for successful networking at the national level is very good indeed.

References

1. Newman, A. J., "Review of Network Management Problems and Issues," National Bureau of Standards, Washington, D.C., October 1973.
2. Licklider, J.C.R., "Potential of Networking for Research and Education," in *Networks for Research and Education*, MIT Press, Cambridge, Massachusetts, 1974.
3. Harslem, E., and J. Heafner, "Aspects of Large-Scale Resource Sharing through Networks of Computers," NTIS No. AD-748927.
4. Treu, Sigfried, and Pyke, "Computer Science Collaboration Via a Computer Network," *Proceedings of Computer Science Conference*, Columbus, Ohio, 1973.
5. Emery, J. C., "Implementation of a Facilitating Network," in *Policies, Strategies and Plans for Computing in Higher Education*, EDUCOM, Princeton, New Jersey, 1976.
6. Greenberger, M., J. Aronofsky, J. L. McKenney, and W. F. Massey, eds. *Networks for Research and Education: Sharing of Computer and Information Resources Nationwide*, MIT Press, Cambridge, Massachusetts, 1974.
7. *EDUNET—A National Computing Network for Higher Education and Research*, EDUCOM, Princeton, New Jersey, January 1979.
8. *Report to the National Science Foundation on the Study to Develop a Research Plan for a Simulation and Gaming Project for Inter-Institutional Networking*, Grant GJ-41429, EDUCOM, Princeton, New Jersey, August 1974.
9. *Final Report to the National Science Foundation on the Simulation and Gaming Project for Inter-Institutional Computer Networking*, Grant MCS75-03634, EDUCOM, Princeton, New Jersey, June 1979 (expected).
10. Segal, R., and N. White, "Management of a Large Computer Network Simulation Project," *Proceedings: Fourth Annual Symposium on the Simulation of Computer Systems*, Boulder, Colorado, August 1976. (Also published in *Simuletter*, *Journal of the ACM-SIGSIM*, vol. 7, no. 4, July 1976).
11. Segal, R., and N. White, "A Simulation Model of a National Computer Resource-Sharing Network for Education and Research," *Proceedings: Computer Networks Conference*, Gaithersburg, Maryland, November 1976.
12. Segal, R., and N. White, "Representation of Workloads in a Network Environment," *Proceedings: Summer Computer Simulation Conference*, Washington, D.C., July 1976.
13. Jones, A., "User Interface Manual for the EDUCOM Network Simulation Model," EDUCOM Report, Princeton, New Jersey, June 1979.

14. Nielson, N., and R. Segal, "Modeling an Inter-Institutional Computer Network," *EDUCOM, Bulletin of the Interuniversity Communications Council*, vol. 11, no. 4, Winter 1976/77.
15. Nielsen, N., and R. Segal, "Simulation of Institutional Behavior in a National Networking Environment," *Proceedings: Winter Simulation Conference*, Gaithersburg, Maryland, December 1976.
16. Emery, J. C., N. Nielsen, B. O'Neal, and R. Segal, "A Simulation Model of a National Network for Education and Research," *Proceedings: 15th Annual AEDS Convention*, Fort Worth, Texas, April 1977.
17. Segal, R., and B. O'Neal, "Dynamic Simulation of a National Resource Sharing Computer Network," *Proceedings of 1978 Winter Simulation Conference*, Miami Beach, Florida, December 1978. (IEEE Publication 78CH1415-9.)
18. Segal, R., and B. O'Neal, "Simulation of a National Computer Network in a Gaming Environment," *EDUCOM, Bulletin of the Interuniversity Communications Council*, vol. 13, no. 3, Fall 1978.
19. Heller, P., "Benchmarking the Price of Computing: Results of a Survey," *Computer Networks*, vol. 1, no. 1, June 1976.
20. Bernard, D., et al., *Charging for Computer Services: Principles and Guidelines*, PBI Books, Petrocelli, New York, New York, 1977.
21. Berg, S. V., "Planning for Computer Networks: the Trade Analogy," *Management Science*, vol. 21, no. 12, August 1975.
22. Weingarten, F., N. Nielsen, J. Whiteley, and G. Weeg, "A Study of Regional Computer Networks," University of Iowa Report, Iowa City, Iowa, 1973.
23. Nielsen, N., "The Implications of Star Computing Networks," *Proceedings of IFIP Congress 74*, North Holland Publishing Company, Amsterdam, 1974.

EDUNET: A National Facilitating Computer Service Network for Higher Education and Research

Paul S. Heller

This chapter is a brief story about EDUNET, how it developed, what its activities are, and what its current status is, as of the 1978 EDUCOM Fall Conference. It is worthwhile to begin with the set of institutions that formed the Planning Council on Computing in Education and Research in 1974. This group of twenty-three universities convened to investigate the possibilities of national networking. EDUNET is a special project of the Planning Council on Computing in Education and Research. The institutions marked with asterisks on the following list of Planning Council members act as suppliers in EDUNET:

Planning Council on Computing in Education and Research

- | | |
|---|---|
| University of California | *Merit Computer Network: |
| California State University
and Colleges | University of Michigan |
| Carnegie-Mellon University | Michigan State Univer-
sity; Wayne State |
| Case Western Reserve
University | University |
| *Cornell University | *University of Minnesota |
| The University of Chicago | *University of North Carolina |
| *Dartmouth College | *University of Notre Dame |
| University of Georgia | Princeton University |
| Harvard University | *Rice University |
| *University of Illinois | *Stanford University |
| Lehigh University | *State University of New York |
| *Massachusetts Institute of
Technology | University of Texas |
| | *University of Wisconsin |
| | *Yale University |

A total of thirteen members with seventeen different computer facilities act as suppliers.

Before going into more detail on network activities, I would like to define the context of a facilitating network like EDUNET. A facilitating network is only one of three different kinds of networks that coexist: the physical network, the logical network, and the facilitating network. The physical network consists of the hardware of computers and terminals and the electronic means by which they communicate, the telecommunications facilities. In the case of EDUNET, the physical network is not owned or operated by the network. Figure 1 shows that the physical network is made up of several different host computers and several different vendors, including IBM,

Figure 1. The EDUNET Physical Network and Its Computers

CORNELL UNIVERSITY-----	IBM 370/168
DARTMOUTH COLLEGE-----	HONEYWELL 66/DPS-3
UNIVERSITY OF ILLINOIS-----	CDC CYBER 175 (12/78)
MIT-----	HONEYWELL 6180, IBM 370/168
MERIT	
UNIVERSITY OF MICHIGAN-----	AMDAHL 470 V/6
MICHIGAN STATE-----	CDC 6500
WAYNE STATE-----	AMDAHL 470 V/6, IBM 360/67
UNIVERSITY OF MINNESOTA-----	CDC 6400
UNIVERSITY OF NORTH CAROLINA (TUCC)---	IBM 370/165, IBM 370/165 II
UNIVERSITY OF NOTRE DAME-----	IBM 370/168
RICE UNIVERSITY-----	IBM 370/155 II
STANFORD UNIVERSITY-----	IBM 370/168
SUNY/ALBANY-----	UNIVAC 1110
UNIVERSITY OF WISCONSIN-----	UNIVAC 1110
YALE UNIVERSITY-----	IBM 370/158 AP

Honeywell, CDC, and UNIVAC. To connect the user terminals with the supplier computers shown in Figure 1, EDUNET relies on publicly available telecommunication carriers. These carriers are basically of two types: value-added carriers and general communications carriers. Both types are used by EDUNET. Value-added carriers, such as Telenet or TYMNET, provide communication networks specifically designed to provide high quality data communication services. The term "value-added" refers to the fact that these networks provide certain benefits beyond those of ordinary leased telephone lines. For example, they provide code conversion, enabling a variety of terminals to talk to hosts that normally do not support those terminals. The networks also support speed conversion, so that a terminal and the host computer can operate at different speeds. A very important value added is the fact that a user can have essentially complete control over errors in the communications network. The value-added carriers' pricing policies are based on moderate fixed costs and fairly low variable costs. Full cost to the user for the data communications component of a computer terminal session typically ranges between \$4 and \$7 per connect hour.

The second form of telecommunications used in EDUNET is the direct-dial long-distance network. For hosts not connected to one of the value-added carriers, the direct-dial network allows remote use with very low or nearly zero fixed cost, with a fairly high variable cost. Direct-dial data communications cost typically averages \$20 per connect hour. Since the value-added networks do not currently support batch or remote job entry (RJE) traffic, direct-dial or leased lines currently are the only way to provide for both batch and RJE.

The second component of national computer networking is the logical network, which consists of the people who develop computer-based resources, the computer-based resources themselves, and the users of those resources. A sampling of the computing resources available through EDUNET illustrates the logical network concept. As can be seen by the names of a number of different computer-based products in Figure 2, the resources range from a single program, to a collection of programs,

Figure 2. An Abbreviated List of EDUNET Resources

CORNELL	NORTH CAROLINA
PBM/STIRS	JOHNSON CHEMISTRY PACKAGE
TROLL	EXPERTSIM
EFFM	SAS
APPLESCAB	SETUPS I & II
DARTMOUTH	MOTRE DAME
IMPRESS	EMIL
TRIBUNAL	CAI RESOURCES
GRAPHICS	
FIND	
500+ INSTRUCTIONAL PROGRAMS	
GEORGIA	RICE
GIDC	SPEAKEASY
	SAS
	WMDP
ILLINOIS	STANFORD
STAT	SPIRES
	GENTRA
	BALLOTS
	STANFORD WRITING PROGRAMS
	EDUNET DATA BASE
MERIT	SUNY/ALBANY
TAXIR	TRAIL
MIDAS	ASET
CONFER	
GRAPH	
MINNESOTA	WISCONSIN
CAI RESOURCES	TELEMAIL
	WISE
	LEXICO
MIT	YALE
TROLL	LIDA
ACCESS	AUTOGRP
MULTICS	
CONSISTENT SYSTEM	

to a very complex hardware/software system. For example, in the chemistry area, one program of special interest is PBM/STIRS, which enables the output of a mass spectrometer to be compared with a data base of spectral characteristics to determine the unknown compound in the mass spectrometer. The Johnson Chemistry Package would also be of interest to chemists. For many disciplines, different graphics packages and statistical packages are provided by a number of suppliers.

EDUNET Services

The third component of a national computer network, the facilitating network, is most easily defined as all those facilities and services not listed above, but necessary for remote use of resources. In the case of EDUNET as a facilitating network, the full range of network facilitating services can best be placed in three different categories: administrative services, marketing services, and user support services. In administrative services, EDUNET currently provides:

Account initiation	Document acquisition procedures
Network activity measurement	Supplier rate information
Liaison coordination	Benchmarking

Central accounting and billing will be provided later in 1979. By working through EDUNET for account initiation, users can avoid some of the problems often encountered in remote use of computing services. With central accounting and billing, a user institution will be able to budget and control for computing expenses even if several different suppliers are used, since a single bill detailing usage of any number of suppliers can be provided. A by-product of central accounting and billing is the capability of the network to measure its own activity, and for network management such measurement is absolutely essential. Another administrative function of EDUNET is liaison coordination. Each of the Planning Council members have appointed a person to act as their EDUNET Liaison. This person

typically works in the user services group at each member's computing center and has daily contact with local users. He or she is familiar with the various products and services that the facility provides. Another administrative service is a set of simplified procedures for acquiring documents needed to understand and use products available through EDUNET. During the prototype experiment, nearly every EDUNET user sought information about the cost of using an EDUNET supplier facility. Unfortunately, most of the EDUNET suppliers' rate sheets are so complex that it is almost impossible to determine what the exact cost of any given run will be. To give users a general comparison of costs for selected resources, EDUNET also provides benchmark data.

A second set of EDUNET facilitating services concerns information dissemination. In the for-profit sector, they would be called marketing services. Information dissemination services include:

EDUNET brochure

EDUNET News

EDUNET Hotline

Supplier Fact Sheets

Resource Fact Sheets

Sample sessions

EDUNET Resource Data Base

Response to user need requests

In EDUNET there is some overlap between what might be considered marketing services and what can be considered user support services. EDUNET marketing services include such fairly standard items as a brochure for those who are just learning about EDUNET and a widely distributed periodical published four times a year as part of the *EDUCOM Bulletin*. *EDUNET News* is the prime means of disseminating general information about EDUNET and more specific information about some of its services. The EDUNET Hotline, which is a toll-free IN-WATS telephone service, allows potential users in higher education to call EDUNET Central to make inquiries about products and EDUNET services that are available, to request information about terminal communication procedures, and to pose other questions regarding the use of resources. The EDUNET Hotline number is (800) 257-9505. All readers are encouraged to use

this number to obtain further information about EDUNET.

The EDUNET Supplier Fact Sheets are documents that serve both marketing and user services functions. On one or both sides of an 8-1/2 x 11-inch page, the Supplier Fact Sheet provides information about the hardware and system software that is available from a supplier. In addition, the sheet provides a small list of special resources including very short descriptions of each resource. The purpose of the sheets is to give the interested user an overview of the variety of existing suppliers while indicating the type of special resources that are available. In order to provide more detailed information about special resources, EDUNET has also developed a set of Resource Fact Sheets. These sheets provide information about a particular resource available through EDUNET. For example, NDTRAN is a simulation language developed and available at the University of Notre Dame Computing Center. In the Resource Fact Sheet we present an abstract, a brief description of what the program does and how it might be used, indication of the available documentation, the supplier of the resource, and the person to contact for more information. Every Resource Fact Sheet also gives the EDUNET Hotline number and the address of EDUNET Central. Both sources can provide more information about any of the available resources.

Other sets of documents that have value for marketing and user services are sample sessions. A typical sample session has been developed by Dartmouth College for the software and data base facility called IMPRESS. It consists of four pages that show the dialogue between the computer and the person at the terminal. On the right side of each page, in italics, are explanations of and comments on what the computer is producing and what the operator is entering on the keyboard. A sample session, in many cases, shows users how to use the resource for other purposes by simply changing commands at one or more points in the session. A sample session always shows the sequence of commands for logging on to a system, invoking the particular program of interest, ending the program, and signing off the system.

One of the most valuable facilities provided by EDUNET is

an on-line catalog of resources available through EDUNET. Called the EDUNET Resource Data Base, this on-line catalog has been developed and enhanced during the past two years. It runs on the Stanford computing facility under the SPIRES information retrieval system. The EDUNET Resource Data Base consists of four related subfiles: resources, suppliers, documents, and people. The most frequently used subfile is the resources file. In the resources file, each resource available through EDUNET is described in terms of eleven characteristics. These characteristics include the name of the resource, and can provide abbreviations and aliases as well. Also included are a description of the resource (which is much like the abstract presented in the Resource Fact Sheet), a sequence of search keys (which can include keywords not included in the description), the type of the resource (interactive, batch, or both); and the language of the resource (FORTRAN or Pascal, for example). A characteristic called "available at" provides the name of the EDUNET supplier for the resource; "available on" is the computing facility where the resource resides; "access" gives information about invoking the resource once the user is signed-on to the system; and "documentation" includes the titles of documents describing the resource or its use, as well as the price and availability of such documents. Support level is indicated by three characteristics: the degree of on-going development of the resource by the supplier, the degree to which errors and bugs in the resource will be fixed, and the level of user support service that is provided by the supplier. Finally, the data base lists a contact person or persons who can provide additional information about the resource and its uses. Currently the data base holds descriptions for more than 500 resources. A facility might be a single program, a collection of related programs, or a complete hardware/software system like the MULTICS facility at MIT.

The resource data base is used by the EDUNET Central staff when an EDUNET Liaison or a potential user calls on the hotline seeking to find a desired resource. If the user knows the name of the resource, that name can be entered on the terminal and, if the resource is in the file, its abstract and other informa-

tion will be retrieved for printing at the terminal. More typically, the user does not know the name of the resource, but can provide some descriptive terms. When these terms are entered into the terminal, the SPIRES facility searches the entire resources file for name, description, and key fields that match the keywords entered. Resources that have matches on the keywords may then be retrieved either for further application of additional search terms or for printing of the description or other parts of the record for each resource. Based on experience to date, the cost of a ten-minute search is typically between one and two dollars.

Another service provided by EDUNET that facilitates locating specific computing resources is the use of a general-purpose electronic message system called TELEMAL, which runs on the University of Wisconsin-Madison computer facility. TELEMAL is a terminal-based message system used on a daily basis by EDUNET Central, the EDUNET Liaisons, and others who need to contact EDUNET people. Through TELEMAL, EDUNET Central can send broadcast messages to the EDUNET Liaisons describing the need for a particular computer resource. The broadcast capability in TELEMAL is used when a search of the data base has not turned up any resource to meet a particular user's need. Through the broadcast capability, EDUNET staff can describe a need to all EDUNET Liaisons, who can then examine their own experiences to see whether any resources not listed in the data base might meet the need. In cases where such a broadcast message does not result in any resources that meet the specific need, staff members use another method of describing the resource to a much larger community in higher education, the EDUNET Want Ads. Figure 3 shows the EDUNET Want Ads that appeared in a 1978 issue of *EDUNET News*. In this issue, there are seven descriptions of different requests for computer-based services. This column reaches roughly ten thousand people who receive the *EDUNET News*, and readers are encouraged to contact EDUNET Central if they are aware of products that can meet the needs described. One interesting and unexpected result of the EDUNET Want Ad column was identification of other potential users who had the same question

Figure 3. A Sampling of EDUNET Want Ads

EDUNET Want Ads

One of the uses of the EDUNET Hotline has been for inquiries from persons seeking particular programs, packages, or types of service. If you have a resource that might meet one of these needs, please call or write EDUNET Central.

In response to an earlier request for identification and evaluation of various discrete and continuous modeling packages, the EDUNET liaison from the Merit Network supplied the name of a University of Michigan professor who was willing to provide information on this topic.

Florida State University provided information about a grant management system for fine arts to the University of Illinois, which was looking for administrative programs relating to the performing arts (see "Progress of a Want Ad" on this page).

Current requests are as follows:

OSIRIS The University of Illinois is looking for a version of OSIRIS that operates on a CDC machine and an evaluation of the CDC version.

Inventory Program The College of Education at the University of New Mexico is looking for an inventory program to keep track of equipment and facilities.

Time Series Analysis Programs The School of Business Administration at the University of North Carolina at Chapel Hill is looking for the following ALGOL programs by John Hampton: USBD, USPE, USES, USFO, UTID, UTPE, and UTEB as well as for another package that contains PDQ, ESTIMATE, and FORECAST.

Handicapped Students The University of North Carolina is collecting information on devices and application programs for handicapped students. They are emphasizing

those for blind and deaf students but are also interested in work with dyslexia and other learning handicaps.

Structural Design A civil engineer at the University of Minnesota is seeking a program in the field of structural analysis and design of post-tensioned members that can analyze rectilinear and nonrectilinear structures with variable stiffnesses.

CAI in Statistics A Clemson University professor would like to know of any computer-based materials designed specifically for statistics instruction.

Agricultural Data Bases Bases containing agricultural data, particularly relating to the commodities market, are being sought by a Northern Illinois University graduate student who is compiling a bibliography of available data bases in this area.

as that posed in the EDUNET Want Ads. These users asked EDUNET to inform them of any products that were turned up as a result of the ad.

The third set of facilitating services provided by EDUNET is user support services, including:

EDUNET Hotline
TELEMAIL
EDUNET Resource Data
Base: supplier file and
resource file
Supplier/resource docu-
mentation library
Sample sessions

Communications information
and consulting
Access information
Log-on instructions
Difference tables
Consulting
Referral

As I indicated previously, many of the EDUNET services function in both marketing and user support roles. For example, while potential users call on the EDUNET Hotline to learn if specific resources are available, established users call to ask EDUNET Central how to use a specific resource, how to establish an account, or how to get further information. TELEMAL also supports users who have queries about specific resources that do not require an immediate answer. Likewise, the EDUNET Data Base can serve for user support as well as marketing. EDUNET staff members can look up access information for a resource in the data base to help a user gain access to a specific resource once logged-on to the supplier.

The supplier file, a separate subfile in the EDUNET Data Base, contains general information about each supplier that applies generally for all resources available from the supplier. In addition to a more detailed description of hardware and system software than is provided on the Supplier Fact Sheet, the supplier subfile includes the operating hours of the supplier facility and similar information. The supplier file also lists the procedure for logging-on to the supplier facility using direct-dial, Telenet, or TYMNET access; rate information; name and telephone of persons at the supplier facility and their responsibilities; information about consulting services available, including on-line consulting capabilities; and information about documentation, including who to contact and how to order.

Another user support service used in conjunction with the hotline and TELEMAL, is the supplier and resource documentation library maintained at EDUNET Central. Documentation includes sample sessions, access information, log-on instructions, consulting, and referral services for user support information, as well as a very handy EDUNET reference table called a difference table. Figure 4 is a very brief example of a difference table prepared for the DEC facility at Carnegie-Mellon University. The difference table for each supplier facility defines and tells what actions result from some of the commonly used system commands. For example, a user wishing to delete a character already typed can use the difference table to see which key or what command is used. In Figure 4, the DEC user can see that the delete key should be used for deleting a

Figure 4. Sample Difference Table

Institution: Carnegie-Mellon University		
Hardware: DECsystem-2040 and DECsystem-2060		
Operating System: TOPS-20		
EDUNET Liaison: Fran Craig/Chuck Augustine		
Item	Document if different from	
first actions	(none, logon beings automatically)	LOGIN userid
		password
		account
to delete a typed character	Control H or backspace key	DEL-delete key;
		sometimes
		labeled HUBOUT
to interrupt a program and return to command mode	break or attention key	2 "Control C's"
explanations	EXPLAIN term	HELP term

character. These common system commands vary from one system to another, and it is particularly frustrating for someone who uses a variety of different systems to have to go through volumes of documentation to find answers to such commonly encountered situations. There are approximately thirty to thirty-five different system commands included in the table.

Network Activity

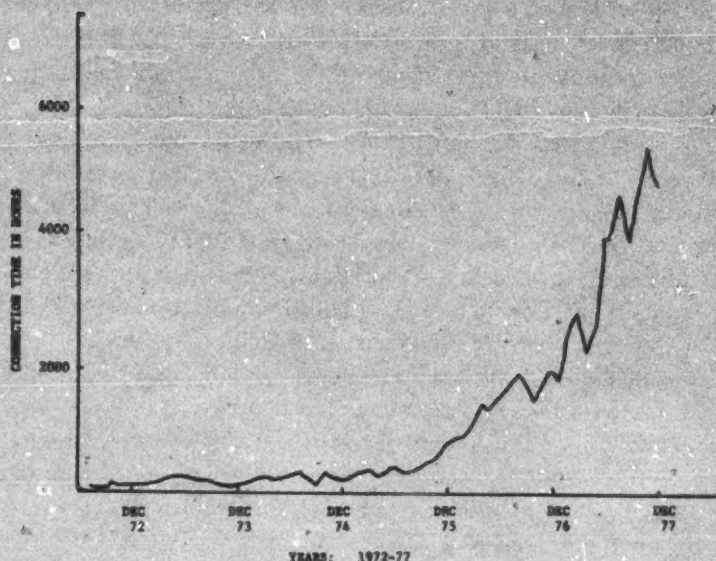
Measurement of the volume and type of activity in EDUNET is currently based on voluntary and somewhat inefficient procedures, but the information gathered is most useful. We have used our account initiation procedures to initiate 103 accounts. Four account holders are non-domestic. As of Novem-

ber 1978, EDUNET user traffic is estimated in the range of \$20-\$25,000 per year. When compared to the amount of service provided by a typical college computer center, this \$25,000 annual figure certainly must look small. However, I think it is useful to look at experience in one other network situation to estimate how EDUNET traffic might grow.

Figure 5 shows a plot of the traffic in the Merit Computer Network, a three-host network that has been operating for approximately seven years. The Merit network provides telecommunication links between computing facilities at the University of Michigan, Wayne State University, and Michigan State University. In addition to providing telecommunication service, the Merit network provides a variety of facilitating services. The graph in Figure 5 shows the number of connection hours per month over a five-year period. In the first two to three years of network activity the volume of traffic was quite small. However, in the three most recent years, the graph shows very substantial growth in network traffic. Although the graph reports results only up to the end of 1977, more recent figures indicate that traffic has continued to grow at the rapid rate recorded in 1977. Where is EDUNET on this growth curve? Experience to date does not provide sufficient evidence to be sure, but I would guess that EDUNET is probably somewhere around the December 1973 point in the curve. We are looking forward to a period of growth during the next several years.

During the prototype operation of EDUNET, staff members learned that there can be a very long lead time between initial contact with a potential user and the opening of an account. Therefore, it is also useful to look at other measures of user contact. EDUNET staff members have made forty-six campus visits and conference presentations during the past year of prototype operation. The *EDUNET News* circulation is approximately 10,000, of which 2,000 subscribers also receive the *EDUCOM Bulletin*. The EDUNET Hotline, a toll-free IN-WATS service, has received approximately 1250 calls since its installation about fourteen months ago. Either through calls on the hotline or through written communication, EDUNET has dealt

Figure 5. Merit Network Growth: Consumed Connection Time (in hours)



with 172 universities and colleges and 75 other organizations. In addition, we have had contact from eleven countries outside the United States. It is interesting that the value of a national facilitating network such as EDUNET may prove to be greater for users outside the United States. For example, during a recent visit an English group responsible for coordinating research computing was able, through a single contact with EDUNET, to learn about computing activities at more than a dozen EDUNET supplier locations.

The Long-term Perspective

In order to obtain a long-term perspective on where EDUNET stands in the development of a national computer service network, it is useful to look at events during the past decade. In 1967 EDUCOM conducted a summer workshop at Boulder, Colorado, in which participants looked at some of the possibili-

ties for and impediments to developing a national network. In fact, the name EDUNET was first used over a decade ago in that workshop. Approximately five years after that first session, in the Winter of 1972-73, EDUCOM, with National Science Foundation sponsorship, held three general working seminars. In these seminars, potential network participants came together to look at specific issues in networking for higher education. They developed the concept of a facilitating network and recognized that the problems in national networking were financial, organizational, and political rather than technical, as it had appeared in 1967. Seminar participants also recommended that a small group of institutions form a committee to look at some of the operational issues in national networking, and in 1974 the Planning Council was formed by twenty-three universities.

During its five-year life, the Planning Council sought to understand more completely the issues of forming a network; to gain some experience in operating a network; and, if analyses indicated that permanent establishment of a network was worthwhile, to define the organization of such a network, including development of a comprehensive business plan. That analysis was made in 1978, and the Planning Council recommended that a national facilitating network be established. Plans for the network are outlined in the comprehensive business plan for EDUNET.

In the late fall of 1975, EDUNET was first demonstrated at the EDUCOM Fall Conference in Portland, Oregon. During that demonstration three university facilities connected to the Telenet network made services available: Dartmouth College, MIT, and the bibliographic retrieval facility at the State University of New York Central Office.

In 1976, a major milestone was reached in the development of the prototype EDUNET with the appointment of EDUNET Liaisons at each of the Planning Council institutions. Also in 1976, *EDUNET News* was first published, and a series of experiments were conducted by Planning Council participants. Included in those experiments were the design and initial development of the EDUNET Data Base and attempts to use existing electronic mail facilities, including a commercial system called

Hermes that was available from Bolt, Beranek, and Newman.

In 1977, EDUNET began to use an inexpensive and flexible electronic message system called TELEMAL, developed by the University of Wisconsin. The EDUNET Hotline was installed, a pilot marketing effort was launched, and the staff was increased to include a full-time person in the marketing area. Rudimentary account initiation procedures were developed, and EDUNET began to facilitate access to a variety of resources. In late 1977, as a result of several meetings of the Planning Council participants, a set of EDUNET objectives were defined and endorsed by the group. These objectives were very long-term directions in which those who participated felt the network effort should develop.

In 1978 a subset of representatives from the Planning Council worked together to develop the EDUNET Business Plan. In Chapter 4 Robert Scott indicates how this plan was developed, what it contains, and what its recommendations are for the future of EDUNET. As indicated earlier, EDUNET is now well established as a prototype facilitating network and looks forward to a period of rapid growth as it becomes a self-sufficient operating activity of EDUCOM. With the public unveiling of EDUNET at the Fall Conference, the vision of participants in the 1967 EDUCOM summer study is being realized.

The EDUNET Business Plan

Robert H. Scott

Introduction

This chapter describes the planning process that was conducted over the past two years to develop specific objectives for the national computer network known as EDUNET. The sections that follow outline the manner in which objectives and a specific plan were developed and summarize the specific plan. The full version of the EDUNET Business Plan is available from EDUCOM.

The Planning Council

The EDUCOM Planning Council on Computing and Educational Research was formed in 1974 by twenty-three major universities that sought to discuss, develop, and experiment with ways in which universities might increase cooperation in the use of computing resources and develop common approaches to problems associated with the provision, management, and use of computing. During the period between 1974 and 1976, a number of experiments and initial development activities were conducted by the council. As a consequence of these experiments, a number of policy and operational issues were identified. In late 1976 and early 1977, staff from Planning Council member institutions conducted a number of planning sessions referred to as an "idealization" process. Through the idealization process, Planning Council members sought to plan for network activity, resolve disagreements, define problems, and,

most important, to postulate potential network objectives that were forward-thinking and unconstrained by current commitments.

After reviewing the results of the idealization sessions, the Planning Council appointed a smaller Planning Group to consolidate the results of the sessions and to develop a concrete, achievable plan for the activities to be carried out beginning in 1979, when the five-year life for the Planning Council would be concluded. In the summer of 1977 the Planning Group consolidated the results of the idealization sessions into a coherent set of objectives to serve as a guide for developing a network activity for the next five years. The second activity of the Planning Group was achieved through the development of a formal business plan for EDUNET.

A business plan was selected as the planning vehicle for several reasons. First, such a plan would have to be both complete and consistent. Second, it would address formally the issue of financial viability. Third, the result would be readily subject to evaluation by potential participants. Fourth, it would include all the needed technical and financial tests for realism of feasibility.

In summary, the EDUNET Business Plan addresses the market for computing in higher education, the opportunities that computer networks provide, and the different ways in which networks can be developed. It includes an analysis of the options, a recommendation, and a list of specific follow-up activities. This plan has now been adopted by the Planning Council and by the EDUCOM Board; it is currently being implemented.

Context of the EDUNET Business Plan

The business plan begins with a description of the market and the marketplace for computing in higher education. It outlines current expenditure levels and growth rates for computing and addresses the manner in which expected advances in hardware and software technology will effect the place of computing in higher education. Current methods of filling computing needs on campuses are then summarized. Some institutions

choose to acquire computer services remotely; some provide all services through a central facility; some plan a balance between central and distributed computing; and others follow mixed strategies.

One important aspect of this marketplace is the decision process universities use in acquiring computing services. Most institutions budget directly for computing resources. Once a budget for computing has been established at such an institution, capacity is fixed, and the only choice is allocation of the fixed resource among all competing demands. As computing usage grows, rationing must be imposed or an additional service acquisition must be made. For a smaller number of universities, computing is budgeted indirectly rather than directly. In such institutions, computing budgets represent the totality of numerous, individually-determined decisions to acquire computer services. Projected demand is aggregated and a set of services acquired to meet only that demand. Universities in the second group can make more rapid changes in computing services in response to changes in demand.

The business plan describes the network as an alternative to traditional modes of computing service acquisition, and examples of successful networks and of network products are discussed. Several types of networks have been successfully established within higher education in the United States: some serve particular disciplines, some serve local geographic areas, and still others serve governmental units. Numerous software and data products have been developed that are particularly adaptable to network use. Prominent among them are those for which the cost of transfer is particularly high and for which use is significant but not substantial enough to justify the fixed cost of maintaining the product locally. In addition, networks can be used effectively for preliminary study of, and experimentation with, new services; for load sharing and load leveling; and for the exportation of the results of research.

Opportunities

The plan discusses computer network opportunities as seen

from four viewpoints: the service buyer, the service seller, the computer center, and the new user. The service-buying institution sees the network as a vehicle that will provide more opportunities than would otherwise be available. Through the network, these institutions can obtain alternative sources of service, lower prices (because of price competition), improved service quality, and a wider range of computing services. The service-selling institution sees the network as an opportunity for the distribution or minimization of fixed costs and for the improvement of economy of scale. For the college computer center, a network represents an opportunity to increase control over campus computing, to better predict demand, and to offer faculty the opportunity to export the results of research. For institutions, computer centers, and faculty wishing to buy or sell services, as well as for those who wish to consider new opportunities, the network represents a vehicle through which different approaches to service acquisition can be considered and evaluated.

Options and Analysis

The EDUNET Business Plan describes several of the available network organization options. In fact, the options for network service and organization represent a continuous spectrum of levels of service and types of organizations, ranging from the extremely small to the large and comprehensive. In selecting specific points on this spectrum for further discussion, the plan seeks to identify options that are realistic, affordable, and achievable. Those options must have broad potential interest and must provide a focus for substantial amounts of agreement. In particular, three options are considered: an Information Exchange option, an Active Facilitator option, and a Promoter/Innovator/Investor option.

Under the Information Exchange option, the network organization provides few services. The network organization acts primarily as a vehicle through which information is exchanged and services can be identified. Under the Active Facilitator option, information exchange becomes more active, and a certain number of network services are provided, including the

establishment of accounts, user services, central billing, and information exchange. Under the Promoter/Innovator/Investor option, all current and projected EDUNET services are provided, and the network organization strives actively to develop new services, to promote network use, and to develop network activity significantly.

Following the descriptions of the options, the plan discusses their economics and establishes criteria for selecting an option from EDUNET. According to those criteria, the proposed option must have a good chance of success and must be economically self-supporting. The network option selected must be able to grow slowly and continuously, and it must pass the "iron test," i.e. the cost for the network must not exceed the net value it provides to member institutions. In the EDUNET Business Plan, support for a network likely to be available from institutions of higher education is projected, and the Active Facilitator option is selected.

EDUNET Services

The Active Facilitator option, known as EDUNET, is now being developed by EDUCOM. Under this option, a number of network services will be provided. EDUNET will:

- develop a catalog of computing and computer-related services that are available;
- maintain a machine-readable data base of resources;
- initiate accounts for users at supplier institutions;
- provide a central billing function for all services that flow over the network;
- manage a toll-free "hotline" for inquiry;
- provide a moderate level of consulting with detailed questions being referred to technical experts at supplier institutions;
- acquire and distribute documentation;
- measure and control traffic levels and other activity;
- provide market services activity; and
- encourage members to develop new software and data products.

The network is now being formed and will be open for membership in early 1979. Initial interest will be measured in the Spring of 1979, and a decision on whether to proceed will be made at that time by the Planning Council. If sufficient interest exists, the network will begin operation on the first of July, 1979.

Policy Issues in Networking

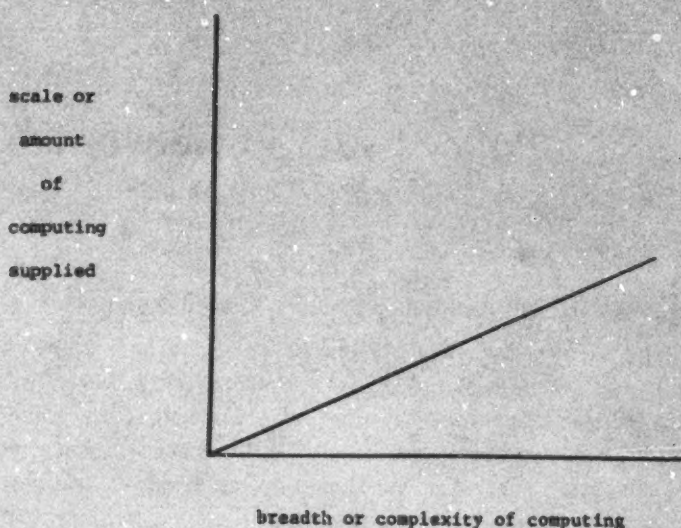
William F. Massy

University Institutional Policy in a Network Environment

The workshop on institutional policy regarding networking, led by Dr. William Massy of Stanford University, began with identification of a number of alternative objectives for academic and other computing at a university. With respect to education, the categories were: 1) general instruction (such as computer literacy), introduction to programming, and elementary computer sciences; 2) problem-solving computing as represented by the use of computers to exercise models (and build simple models) in engineering and management science; 3) access to specialized models and data bases relevant to particular courses (for example, TROLL); and 4) computer-aided instruction and tutorial applications. An analogous classification exists for research, in which levels are distinguished by the required amount of general computing and computing based upon special algorithms and data bases. Administrative computing tends to be more general in terms of the resources required and more institution-specific in terms of data structures.

Computing can be described by a two-dimensional diagram with scale or amount of computing on the y-axis and complexity or breadth of computing on the x-axis (Figure 1). At most campuses computing is evolving towards increased complexity and breadth without a commensurate increase in total scale, at least as measured by the amount of resources applied. Certainly this is true at the computer-center level as more and more resources are channeled into minicomputers.

Figure 1. Two-Dimensional Diagram of Computing Supplied by a Campus Computing Center



One of the most important attributes of national networking is that it permits a movement toward the availability of increased complexity and breadth on any given campus, *without* requiring a commensurate increase in scale. This is possible because the cost of system developments needed in the expanding number of fields that depend on computing can, where resources are specialized and expensive, be spread over a larger base of users.

There was consensus that the use of intrauniversity budget allocations or "funny money" for a high proportion of an institution's computing needs, combined with embargoes on the spending of funds outside the institution, would seriously inhibit the development of disciplines in the university that are dependent upon computing of increased complexity and breadth. Too strong a commitment to in-house computing resources is short-sighted and suboptimal. Where central resources are allocated for computing, it should be possible for some of

these funds to be spent outside the institution. The computer center would then be charged with "competing" to an appropriate extent with other sources of computing and adjusting its services and capacity to respond to the evolving balance of trade in the network. Workshop members agreed that some central university funds should be *earmarked for computing*, including the development of applications for computing, so that they would not be spent on other pressing problems, such as faculty salaries, travel, and scientific equipment.

Several broad principles were enunciated by the chairman and various participants in the workshop. First, where a more general style of computing is involved in a given application, there will be less incentive to demand and to supply it in a general network environment. On the demand side, users now do general computing easily with small machines and minis, so there is less of a threshold effect for small campuses. In other words, small campuses can afford the initial investment required to obtain general computing on campus. From the supplier's standpoint, the sale of general capacity contributes to dollar volume, but it is likely to be unstable and price-competitive. General computing that is not easily moved by the user from installation to installation (e.g., administrative computing with complex and system-dependent JCL statements) may bring additional income, but often adds another difficulty—the hesitant user. The user sees a potential loss of control as a result of being "locked in" to another's installation. Such effects are very real; the user is often captive to prices and costs, and vulnerable to being left in the lurch by the remote supplier.

Specialized computing offers more potential for both user and provider in a networking environment. Specialization may be in terms of hardware (e.g., matrix-processing machines), algorithms (e.g., interactive statistical packages or large-scale mathematical programming codes), data bases, and computer-aided instruction packages. The advantages of operating in a network environment are especially significant when a computer resource is evolving or under active development. In this case, the proximity of the running machine or code to its intellectual godfather(s) is very important. Conversely, portability

would require very frequent updates in software and documentation that, if the system is evolving fast enough, would reduce or negate economies for the users.

Networking also appears to have a comparative advantage where the volume of machine or package use is likely to be very small in any one institution, and where the fixed costs of system maintenance are high. Obviously, in this situation, fixed costs can be spread over a large number of users via networking.

There are a number of barriers to demand and supply in a computer network. On the demand side, the "not invented here" phenomenon is still very strong in many places. Users simply don't prefer resources developed off-campus. Also, the economics of existing capacity and commitments to computer-center staff may make it difficult for administrators to allow users to satisfy demand for computing outside of the university. On the supply side, it takes some effort, and may be expensive, to provide service at a distance. Efficient ways of doing this are still evolving. Also, becoming a supplier means entering into a new environment of competition and uncertainty. This is an environment most institutions are not familiar with and which they are justifiably apprehensive of.

In his keynote speech, William Miller indicated that the biggest long-term barrier to networking is likely to be the difficulty of providing incentives that will call forth a significant number of supplying institutions. There was agreement in the workshops that revenue or profit are *not* likely to be persuasive incentives, nor should they be. The main incentive is likely to be the interest of faculty members in making their intellectual products available to colleagues at other institutions. This interest may stem from a sense of professionalism and pride, but it may also be financial in some cases. The biggest barrier to development of a network supply of specialized resources is faculty reluctance to service other institutions—they may be reluctant to release programs or data bases that they have developed, except where a close colleague or collaborative development/testing relationship is involved. This barrier might be overcome if faculty members were given assistance in servicing external demand. However, at present there is not an

effective coupling between faculty and the people in the computer centers who could assist them. To some extent there may actually be conflict, since computer-center people may feel that it is *their* products rather than those of the faculty that ought to be stressed as resources in the network. Obviously this problem could also be addressed over time. I believe that significant efforts should be made, as a matter of institutional policy, to overcome such barriers.

Institutional Policy on Networking for Small Colleges

The workshop on this topic was led by Sister Judith Cagney of Barat College. I suspect that many of the same considerations that apply to large colleges and universities apply to small colleges as well. For instance, the growing availability of small computers provides new opportunities for instruction and business applications. Small colleges will be increasingly able to afford capacity on-campus for general-purpose computing. Accordingly, their interest in networking will probably develop along more specialized lines than has previously been the case.

Clearly the small college will face financial barriers in making use of the rich menu of specialized computing resources that we hope will become available on computing networks. They will have to choose their areas carefully, but this is the familiar problem they (and indeed all of us) face with respect to selection of faculty. Hard choices need to be made because it is impossible to have faculty members in all fields that the institution would like to cover. Similar decisions will have to be made when acquiring computing resources. The existence of a network like EDUNET will provide more alternatives, and the schools will be able to make more refined choices and change them more frequently than was possible when on-campus computing capacity was the only alternative.

The Role of the University Computer Center in a Network

The general conclusion in this workshop, led by Tad Pinkerton of the University of Wisconsin-Madison, is that computing

and network development has not yet progressed to the point where the role of the computer center in a network environment can be defined with much assurance. Put another way, participants expressed nervousness about the EDUNET policy of "letting things evolve" in a quasimarket environment.

Some of the specific points raised were: 1) whether existing arrangements among institutions would be "grandfathered"; 2) whether it would be possible for network members to "go outside" on a bilateral basis; and 3) how network participants would deal with conflicting institutional policies. My own view is that items 1 and 2 are not likely to be problems. Given the current pricing arrangements for EDUNET, existing arrangements between institutions will survive *de facto*, and institutions are free to obtain resources "in" or "outside" the network. Furthermore, I believe there is no way to plan centrally to resolve conflicting institutional policies within a network.

Similar issues were considered in a workshop on the role of the small college computer center in a network environment, which was led by Carole Lennox of Mills College. As with large colleges, computer center directors in small colleges face a fluid situation where networking is concerned. A decision on network participation is simpler for the small college computer center director in one respect, however: it is unlikely that a small college will want to function as a supplier in a network.

Regarding network participation as a user, the small college computer center faces the same issues as the larger institution computer center. The scale, or threshold, over which one obtains remote services, must be lower for the smaller college, and the amount of money that can be devoted to purchase of off-campus computing resources is often very small. However, the necessity of overcoming "funny money" budget allocation systems and the difficulties of brokering remote computing services to faculty are as severe for the small college as for the large, and are exacerbated by chronic financial pressures.

The small college computer center director is often well aware of institutional limitations and is ready to provide access to remote computing resources. However, particularly for the small college user who lacks a group of on-campus colleagues

knowledgeable in the use of a particular resource, the marketing and user service operations of a national network like EDUNET are important. In fact, since the local computer center director must often enhance the user services function, he or she will also have to rely on national network user support.

Because small college computer center directors are likely to be caught in the middle when remote suppliers discontinue a specific computing service, they are especially interested in seeing national networks like EDUNET develop to the point where the total number of small college users becomes significant to the supplying institutions. At that point, the using institutions would have greater assurance of continued reliable and responsive service.

Minis and Micros in Hierarchical Arrangements

A good deal of the time in this workshop, led by John McCredie of Carnegie-Mellon University, was devoted to a case study of how Carnegie-Mellon University has linked mini- and microcomputers in hierarchical arrangements. Basically Carnegie-Mellon University faculty and administration favor minis and micros, provided they make sense in terms of the specific application and are not incompatible with the institution's general plans for computing.

Requests to purchase minis and micros are reviewed by a computer review board that consists of the provost, the vice-presidents for finance and administration, the chairman of the computer center's User Policy Committee, and the chief operating officer of the computer center. This was reported to be generally similar to the review structure used at Dartmouth College, and both are working well.

Questions raised in the workshop included: Is it really economical to use minis and micros if one counts the full cost, including faculty and student time? How should the computer center handle communications and what are the possibilities (or problems) of sharing the cost of peripherals? Can the computer center address and alleviate the problem of a lack of common languages and dialects across various types of minis and micros?

The chairman originally believed that it was more economical to use minis and micros than to use a centralized system. This view was challenged in the workshop and a lively discussion ensued. There was agreement, however, that the *perceived* service level would be greater with minis and micros, and that it might well be possible to establish a tighter relationship to changing technology curves through their use.

Library Automation in a Network Environment

Immediately after the library automation workshop the co-leaders, Edward Shaw of Stanford University and Patricia Battin of Columbia University, departed for New York City to attend a meeting aimed at furthering the establishment of a national research library information network. That meeting is noteworthy for this summary.

A growing number of universities are coming to the conclusion that a common bibliographic and library processing automation system, and the attendant shared files and intercommunication capabilities, represents an important academic resource. One objective of the Research Library Information Network is to provide the necessary systems and services that must form the core of such an endeavor. To further this and a broad range of other academic objectives, worthwhile efforts are being made by the Research Libraries Group that includes Yale, Columbia, New York Public and, we hope, soon Stanford. Stanford has a vested interest in the activity because, if successful, it will use BALLOTS, a computer-based system developed at that university. Other significant library systems mentioned in the workshop were OCLC, the Washington Library Network, and the University of Chicago.

Remote User Support in a Network

Workshop leader Charles Shomper of the West Virginia Network for Educational Telecomputing (WVNET), began by reviewing case studies from WVNET, Iowa, and EDUNET. One conclusion was that all of the constraints that exist with respect

to providing user support on campus are multiplied and made more serious in a networking environment. A key issue is whether the estimate of one-fourth FTE (full-time equivalent), used as the minimum requirement for serving as a supplier on EDUNET, ought to be increased to one full FTE or more. Experience at WVNET indicates that nearly one full FTE user services staff person is required to support remote users. Assistance is needed for specialized resources and basic consulting, as well as for account initiation and other routine services.

Another agreement that emerged from the workshop was that a successful national network will have to build traffic around specialized computing services and resources rather than around general resources.

The Role of the Regional Networks in a National Network

The workshop on regional networks, led by Louis Parker, Jr., of North Carolina Educational Computing Service (NCECS), reached one primary point of consensus: regional networks exhibit great individuality in relating to a national network. Working relationships within and among regional networks have developed from different traditions. Consequently, relationships between them and a national network like EDUNET will also vary.

NCECS has had some experience marketing EDUNET resources through an experiment with the prototype EDUNET funded by the Planning Council on Computing in Education and Research. Their efforts led to a good deal of success in making EDUNET resources available to the institutional users of the North Carolina regional network. In this case, a strong user services staff had developed a tradition of service to users in colleges across the state. However, discussion in the workshop indicated that one should not expect this to be the case uniformly for regional networks across the country. Indeed, there is likely to be as much variety in the response of regional networks to EDUNET as there will be in the responses of individual colleges and universities.

Sharing Resources for Instructional Support

A main question considered in this workshop, led by David K. Miller of Dartmouth College, was "how do faculty share resources with each other?" Mechanisms such as professional associations, publications and pre-publications, informal contacts, and electronic mail were mentioned. National computer networking obviously has the capacity for improving some of these communication modes.

To effectively utilize a national computer network for sharing instructional resources, faculty members must first communicate well with their institution's computer center. Many workshop participants felt that "faculty typically don't get the word from the computer center" about important things like available and potentially available services. Perhaps the faculty don't ask the right questions, but perhaps computer centers can also learn more about how to publish understandable technical material.

There was also discussion about the content of technical communications from computer centers to faculty members; the content of the EDUNET Resources Data Base was an important part of this discussion. Although useful one-paragraph descriptions are now provided, faculty would like to see more standardized terms and some dictionary development. A general bulletin board, combined with the electronic mail and specialized news letters for specific disciplines would also be helpful.

Authoring Incentives

Workshop leader Richard Ballard of EDUCULTURE focused discussion on the incentives necessary to induce authors to produce instructional media. Computer-aided instruction (CAI) and problem-solving computer-based instructional media were distinguished on the basis of their purpose and performance, the kinds of effort needed to produce them, and the kinds of incentives that might be applicable.

Authors may be attracted to publishing or tutorial packages for the same reasons they are interested in publishing textbooks.

As with textbooks, all of the information "taken out" of CAI by students was originally "put in" by the author. Also, like text books, CAI packages are very labor-intensive to write. The expenditure of 300 person-hours at a cost of \$25,000 to develop one student contact-hour of CAI was cited as not being uncommon. Finally, CAI programs are relatively easy to protect since they are difficult to maintain and enhance. A more or less traditional type of royalty arrangement for the authors seems to be workable.

Authoring incentives for other kinds of computer-based packages are more complex. Some very effective instructional software packages provide an environment in which students may use the computer effectively for problem-solving or exploration. An example is a simulation program that might be exercised in conjunction with a business school case study. Such software packages are much easier and less expensive to produce than traditional CAI because the student is providing a great deal of the "value-added" and the software can be less structured. The development of this type of package is harder to reward, especially since, to date, publication of such packages has not qualified as "academic publication" in the promotion and salary-setting processes of most colleges and universities. This is unfortunate, because the development of simulations for use as teaching aids often requires a high level of intellectual input and creativity, and their existence can make a significant difference in the way in which certain courses are taught. Certainly this is an area of institutional policy that should be addressed. It will become more important as national computer networking makes such packages available to a broader range of institutions.

Greater Productivity for CAI and CMI Programs

The chairman of this workshop, Kenneth Bowles of the University of California, San Diego, is working on CMI (computer-managed instruction) development that differs from the two categories of CAI mentioned in the previous workshop. Bowles' work is aimed at improving the productivity of proctors

with respect to the grading of quizzes, exercises, etc. Existing CMI routines are resident on minis and microcomputers, although file transfers from those machines to a central processor are planned. Bowles' development group hopes to develop regional or even national caches of expertise from which exercises and exams could be disseminated, and to which they could eventually be returned for grading. This is the area that is most relevant to networking, although heavy use of a national network like EDUNET surely will not come to pass very quickly.

The CMI portion of the emerging CAI portfolio is interesting because it addresses one of the most difficult areas of teaching. Large-scale administration of testing, grading, and assignments is both intellectually demanding and highly repetitive and dull. Bowles' investment in the development of a CMI package on a mini- or microcomputer was estimated to be in the range of 50 rather than 500 hours. However, it is not clear whether one should make a comparison of development time and cost to student contact hours, which was used as the basis for the estimate of CAI-tutorial package costs.

Federal Policy Issues in Computing

Workshop participants, led by David Mintzer of Northwestern University, agreed that there is currently no coordinated federal policy on the acquisition of minicomputers by colleges and universities other than the federal overview that is applied to equipment in general. General federal overview has not been effective in providing any kind of coherent force vis-à-vis minis. However, discussants agreed that the need for federal policy on minicomputer acquisition is, at best, a debatable issue. It would be very difficult for the National Science Foundation to really get a handle on the minicomputer question, although it might be desirable for them to influence the development of effective minicomputer networks on campuses through grants and contracts.

Another area of discussion concerned telecommunications. Recent events involving the Federal Communications Commission, the telephone company, and the IBM Corporation were

discussed. It was agreed that competition in telecommunications is generally desirable so far as computer networking is concerned. However, the really important decisions regarding telecommunications regulation will be made on a political level. EDUNET users and suppliers, and EDUCOM, should be alert for opportunities to become involved in policy making in this field for example with respect to providing testimony to government agencies and legislators.

Another concern, which did not receive much discussion in the workshop but is nevertheless of great importance, is Internal Revenue Service (IRS) policies. Current IRS interpretation of unrelated business income and resource sharing means that the main benefits to resource sharing through a network like EDUNET will have to be academic rather than financial. The objective of providing breadth of instruction and research resources may be satisfied by a college computer center, but the "bottom line" of the computer center cannot be an incentive to supply. If national networking is to prosper, it is vitally important that the IRS rule that such resource sharing does not expose an institution to a potential liability for unrelated business income taxes or reporting.

Conclusion

All in all, it appears that the workshop sessions served to ventilate many important issues connected with institutional policy in a network environment, and improved understanding of those issues. It will be interesting to compare the sense of the workshops at the 1978 EDUCOM Fall Conference with that of workshops on the same subject at future conferences, if EDUNET is as successful as many of us hope and trust it will be.

Facilitating Services for Networking

Tad Pinkerton

Introduction

The facilitating services workshops at the 1978 EDUCOM Fall Conference focused on marketing, delivery, pricing and billing, and (especially) ongoing customer support of network resources. The great variety of subject matter presented in these workshops makes a brief summary nearly impossible. Each of the workshop leaders brought to bear a few years of experience and planning in regional networking, the Planning Council prototype network, the EDUCOM Network Simulation Project, or the data communications industry. We tried to pass along to attendees, in a matter of an hour or two, the wisdom gained from those experiences. While we can compress the learning period somewhat in this way for those not previously exposed to networking, I believe it does take time to assimilate and think through the implications of this new way of delivering computing services.

Even if we have been successful in bringing others to a level of appreciation and understanding of network services, it is important now for EDUNET to move from its present club-like state into a broader enterprise phase.

Tad Pinkerton is Director of the Academic Computing Center at the University of Wisconsin-Madison. He has been a member of the Technical Committee of the EDUCOM Planning Council on Computing in Education and Research since 1977. His computer center participates in the prototype EDUNET as a supplier of services, notably an electronic mail system used for EDUNET administration.

The New Networking Game

We have much yet to learn in this new environment. For one thing, the nature of the network population will change. Instead of dealing almost exclusively among a group of twenty-three major universities, each of which already has 99 percent of all the computing services it needs, we expect to see a large number of smaller institutions as regular members.

In one of the workshop presentations, I suggested that national networking in higher education is a game for up to five players:

- a local customer who wishes to access a resource at some other university;
- the local computing center from which this customer normally receives service;
- the central network organization;
- the remote computing center offering the resource sought by the local customer; and
- the "remote expert" who created the resource in the first place and may still be helping the computing center maintain it.

Each of the players in this game approaches it with different motivations and a different level of enthusiasm. Only as we gain experience with a larger-scale network will it become clear which mix of motivations and enthusiasm tends to predominate and shape the character of network services. For example, will the urge to make a profit dominate a supplier's concerns, or will a drive for institutional prestige or personal reputation on the part of resource creators be more significant?

Generic Versus Specialized Services

There has been much speculation at this conference on the relative popularity of generic and specialized services. In the first category are common resources like SPSS and ICES. In the latter, are the unique products of individual research and

instructional efforts not distributed and used on computers across the country. Both kinds of resources will be marketed and used on EDUNET, but their relative mix is very hard to predict. Many have expressed the opinion that generic services will gradually give way to specialized services as predominant network resources.

The national networking scene is really more complex than the game model suggests. At the very least there are some important additional players. Network technology offers a bewildering array of options and opportunities that are constantly evolving. Granting agencies may come to play a large role in influencing network usage, since networking offers an unparalleled opportunity for rapid and effective nationwide distribution of ideas and research products. Finally, university administrators will have an important role in the financial and policy aspects of membership in network organizations.

To date, efforts in promoting national networking have been largely top-down: administrators, computing-center directors, and network central staff have done the bulk of the planning and experimenting, as well as the evangelizing. In my opinion, the key player in the game is the faculty member or academic staff specialist who will be both an end user and a creator of network resources. This player has the greatest direct interest in resources, and the motivation to use them in teaching, research, and administration.

During prototype network activity in the Planning Council, a dramatic surge in the development and marketing of network resources occurred when EDUNET liaisons were identified and involved. User services staff members got right down to business and created something tangible, whereas the Policy Board and Technical Committee representatives had done more talking. As more faculty become involved in EDUNET activities, we can expect further concrete developments in the creation and use of network services.

Commitment to Networking

At the start of the 1978 Fall conference, I sensed a mood of

caution and a feeling of uncertainty among participants who were experiencing networking for the first time. For lack of a sense of confidence in networking, they may wish to return home and recommend that their institutions hang back for a year or two in order to learn better how networking can fit into an overall computer services plan. However, if many of them still feel hesitant at the end of the conference, EDUNET is in danger; there won't be anything left to join in another year if everyone expects to watch others launch the enterprise.

Participants have had a number of discussions during the conference about the costs of being regular members and suppliers of EDUNET. I think it is relatively clear in both cases that usage-sensitive costs will be higher than fixed costs. Since the best model for EDUNET is one in which a very large number of institutions individually create a small amount of network usage, each institution should have to pay very little to play the game.

In summary, I hope participants discovered, in the course of attending this conference, that national networking is non-threatening, not costly, and has great potential for bringing real benefits into the computing environment at their institutions. I extend an invitation to participants and others to join us, then, in making EDUNET a real success.

Network Resources

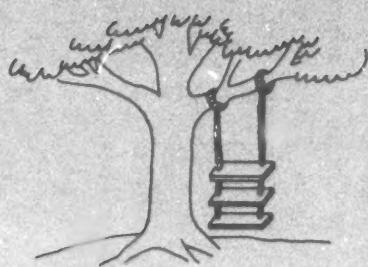
Barry L. Berman

The scenarios depicted in Figure 1 represent a multitude of potential problems that can be answered by EDUNET. By using EDUNET, users can obtain access to "what the user needs" if their home institutions can't provide that solution locally. By the way, "what the user needs" could be a program, a package of programs, an electronic message transfer system, a language processor, an operating system, a data base, or an entire computing system. During the EDUCOM conference, attendees saw (and tried out) just a sampling of the resources available through EDUNET. Yet the resources workshops and the resource rally exposed those who attended to a vast array of network resources in a variety of disciplines. These resources can be used in research and teaching by a truly heterogeneous distribution of people. EDUNET offers something for everyone from the major university administrator to the small college faculty member, the federal government employee, or the librarian. The range of resources cited in workshops during the Fall Conference illustrates the variety of resources available.

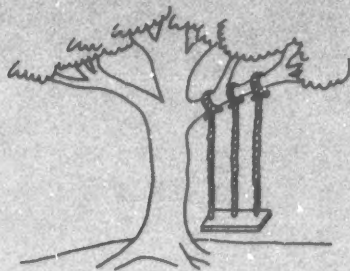
Financial Planning Models

In the resources workshop on financial planning models, Daniel Updegrove of EDUCOM discussed several planning models. One model that has great potential for use among a host of schools is EFPM, the EDUCOM Financial Planning Model. For a full discussion of EFPM see the Winter 1978 issue of the *EDUCOM Bulletin*.

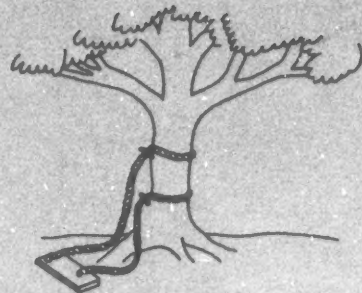
Figure 1. The Pitfalls of Program Design



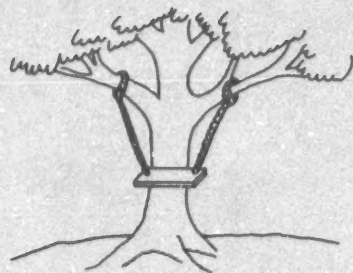
AS PROPOSED BY THE LAB/CENTER DIRECTOR



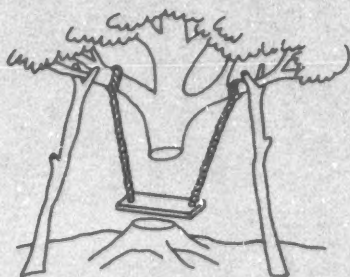
AS SPECIFIED IN THE BASIC PROGRAM PLAN



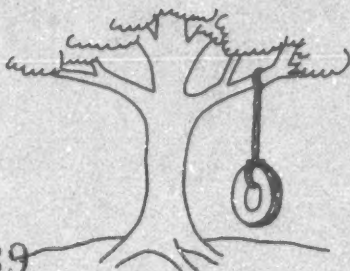
AS IN THE NEGOTIATED SCOPE OF WORK



AS PRODUCED BY THE PROGRAM STAFF



AS INSTALLED AT THE USER'S SITE



WHAT THE USER NEEDED

This package is a prime example of the *raison d'être* for a national network. The fact that the package resides on one host has aided its development considerably. A number of people at universities who have been using the package, have provided feedback to EDUCOM on programming bugs, on enhancements that would be desirable, and on changes that would make the package more useful. In other words, the development of the package has progressed significantly and quickly because the program authors have not had to concern themselves with problems of transferability—problems commonly experienced when a software package is distributed for use by multiple hosts.

EFPM is based on the highly successful computer-based model, TRADES, that was designed and developed by Dr. William Massy and Dr. David Hopkins of Stanford University. EFPM is already in use at Boston College, Carnegie-Mellon University, Harvard University, Yale University, and Oberlin College. At Cornell, where the package is resident, and at Colgate University, Mills College, the University of Louisville, and Stanford University, additional usage is expected. The package is highly attractive because it accommodates individual sets of variables and relationships. It can consequently be used at large schools, small schools, private, and public institutions. EFPM is designed in a very clever fashion. The interactive terminal operating program is separate from the primary model operating program. The primary model program, in turn, runs using institution-specific files that may be specified by the user. Institution-specific files contain definitions of variables and their interrelationships, constraints, report contents, and other parameters that make the file specific to the user institution. Each institution builds its own model through such external, self-documenting data files. The user, who incidentally need not be the person who created the model, runs the model specifying parameters like variable values, functions to be performed, and reports to be generated. The model will forecast for up to ten years, find the feasible range of planning variables subject to certain constraints, or provide information on trade-offs between variables. For example, users could ask, "How

should tuition growth occur given a certain projected faculty salary growth?" The advantages of EFPM as a network service, i.e. available on one host, are fairly obvious. First, users need not concern themselves with conversion or delay in implementation or maintenance. Second, the model's author need not concern himself with design compromises to accommodate multiple systems. Finally, ease of delivery to noncomputer specialists is enhanced by the fact that EFPM is resident on one host. EFPM is being used for financial planning in central administrations, libraries, and even in departments of buildings and grounds at the institutions listed above.

Modeling for the Small College

The workshop "Modeling for the Small College," led by Ronald Segal of EDUCOM, focused on the use and applicability of models for planning and administration in the small college. After reviewing the use of models in colleges, participants agreed that, with the availability of models over networks, administrators at small colleges ought to be able to use models much more than they have in the past. One of the problems to date has been the expense and difficulty of installing batch-oriented models on computers in small colleges. With the advent of networking, these models—like CAMPUS and RRPM from the National Center for Higher Education Management Systems (NCHEMS)—can be used by small colleges without major staff or capital investment. Interactive models may also be accessed over the network. EFPM was cited earlier as an example of a model that could be accessed through a network and adapted to reflect the needs and characteristics of the small college.

By using a model remotely, small college users can benefit from models that are far more complex and require far more storage capacity than would be possible to install on the more limited computers usually available on campus. Often the complexity of the model renders it more easily used by administrators without programming skills. Since small college officers can seldom afford to hire a large staff of programmers and planning professionals, they do not have the assistance necessary to use

many complex models. However, they might be able personally to use a complex model with an excellent interface over a network without assistance from any programmer. Networking promises to make such models available to administrators in small colleges.

Unusual Machine Architecture

Alec Grimison of Cornell University led a workshop on ILLIAC, Array Processors, and Unusual Machine Architectures. EDUNET provides some answers to the need for large-scale numerical calculations typically found in scientific computing. Conventional solutions to large-scale numerical computations include the large shared machines such as the IBM 370, the CDC 7600, the ILLIAC IV, and others. Other solutions include the use of a dedicated mini, like the PDP 11/70. A third solution is to use relatively cheap special-purpose peripheral processors, such as the Floating Point Array Processor at Cornell, attached to a general purpose computer. Operating at 8 megaflops, or 8 million floating point operations per second, the floating point array processor does floating point calculations several times faster than a 370 and much cheaper. The array processor has independent memories for programs, data, and constants, independent floating point multiplier and adder units, and two blocks of 32 floating point registers. Most array processors can be programmed only in assembler language, but Cornell staff have written an array processor FORTRAN cross-compiler. In addition, Cornell has an array processor math library that contains 150 routines and a program development package. In summary, the array processor is very cost-effective for computer-bound operations such as floating-point adds, multiplies, and memory fetches.

Working with the computer center staff, a consortium of Cornell users contributed about one-half of the purchase price of the array processor. This consortium consisted of the Laboratory of Nuclear Studies, the Chemistry Department, Physics Department, and Department of Chemical Engineering. All of these people can now obtain computing services that are com-

petitive with services available from Lawrence Livermore Laboratory. Because they also enjoy obtaining \$10 of computing power from a \$1 device, they have invented ways to use the array processor for additional purposes for which it was not originally intended.

Questions that arose during the workshop were: What will be the long-range effect of the array processor on scientific computing? What will be the role of EDUNET in influencing future developments with regard to the array processor? And, what will be the future role of large facilities like the ILLIAC?

Network Simulation

In the network simulation workshop led by Beverly O'Neal and Alexander Jones of EDUCOM, participants discussed the results of a major EDUCOM research project on computer networking in which a simulation of an interuniversity network was developed and used. The basic design goal of the model was to provide a highly parameterized and flexible tool that would permit the examination of a variety of institutional and network policy rules. The model, in conjunction with data representing the computing requirements, resources, policies, and facilities of the individual institutions, could be used to explore possible network implementations. Both the model and conclusions of the research project are described fully by Ronald Segal in another chapter of this volume.

CAI Authoring Languages

The workshop on CAI authoring languages was led by Dave Kniefel of the New Jersey Education Computing Network. Focusing on the delivery and authoring of CAI courseware via networks, workshop participants discussed future roles for networks, changing technology and economic factors, cost-effectiveness in communications, courseware development costs, and emerging microcomputers.

The underlying theme that EDUNET offers something for everyone was again highlighted during this workshop. Dave

reported that, in a room of twenty-five people, fourteen different CAI authoring languages were represented. I have not done a survey, but I am sure that over fourteen authoring languages are offered as EDUNET resources.

Statistical Packages

In a workshop on Statistical Packages on Networks, Fran Craig of Carnegie-Mellon University led a discussion of statistical packages available through EDUNET and elsewhere. As of November 1978, approximately 131 statistical packages were available over EDUNET, of which 69 were listed under SPIRES on the EDUNET Resources Data Base. In fact, this list was distributed during the workshop. In certain situations it is both feasible and cost-effective to use a statistical software package remotely. The criteria for evaluating and selecting a statistical package are numerous. Formerly, one had only to consider two criteria: 1) What packages were available? 2) Was someone available locally to teach the use of the package that was ultimately chosen? Today, one must consider criteria such as:

- What are the statistical capabilities of the packages?
- Does the package run in interactive or batch mode?
- What level of expertise is required in both programming and statistics to run the package?
- How is the package constructed—separate programs, separate libraries, or a language of its own?
- For what application is the package intended—data analysis or instruction?
- What is the target discipline of the package—medicine, economics, sociology?
- What data management facilities does the package offer?
- What kind of documentation is available for the package?
- How easy is the package to use; i.e., does it have a flexible, extensible command language?
- How accurate are the statistical routines within the package?
- What is the cost of using the package?

Although users generally have remained loyal to one local statistical package, after considering the above criteria, they now find that it is economically feasible and cost-effective to purchase a similar service through EDUNET rather than to implement a new package locally.

Four suggestions were made during this workshop. First, EDUNET should identify schools with data bases and statistical packages. To a certain extent this has already been done. Second, EDUCOM was encouraged to deal with vendors and negotiate special rates for remote users of those packages where royalty problems exist. Third, EDUNET was encouraged to investigate file-to-file transfer capability. Finally, with tongue in cheek, workshop participants suggested that EDUNET develop one statistical package that does everything. For readers who are interested in statistical packages, a very good source of information on statistical packages is *The Comb Ryan Index of Publicly Available Software*.

Social Science Resources

Edwin Kuh and Jim Murphy led the workshop on network resources in the social sciences, focusing for the most part on network resources available for people in sociology and in economics. Typical resources include: 1) TSP (Time Series Processor) which does estimation and time series analysis; 2) TROLL (Time Shared Reactive On-Line Lab), a package that does regression, simulation, data analysis and transformation, and in addition provides access to over 2,200 National Bureau of Economic Research (NBER) data bases; 3) TSAR (Tele Storage And Retrieval) system; and 4) SAS and SPSS, two packages useful in sociology and psychology. By using EDUNET to obtain these resources, faculty often overcome local software limitations, local emphasis on batch computing, and local system inefficiencies or old technology. However, there are reasons why one might not look to EDUNET. EDUNET is facing, and will continue to face, these problems. Data transmission and storage at a remote site can be difficult. One must pay real dollars rather than "funny money" to use remote resources.

Faculty members are separated from local user services when they use resources remotely; and they must learn to use an entire new set of access procedures and systems protocols in order to access a remote resource.

Business and Management Resources

Dr. Richard Bower of Dartmouth College headed the business and management resources workshop. (Dartmouth is a particularly rich source of such resources.) If one were to do a search of the EDUNET Resources Data Base today, one would find that 52 out of the 476 resources listed deal with business or management. Clearly EDUNET has much to offer in the area of business and management resources.

Most of the business and management resources are used for instruction. They vary in length and complexity from exercises in simple calculations to complex tutorials or simulation games. Supplier schools offering business and management programs via EDUNET for remote use include the University of Minnesota, the University of North Carolina, and Dartmouth College.

Health Science and Biological Science CAI

Biological and health science resources fall into three general categories: computer-assisted instruction; statistical packages like BMDP or SPSS; and the bibliographic literature retrieval systems like AUTOGRP at Yale University. In the workshop, participants focused on computer-assisted instructional packages. Dr. Lynda Ellis of the University of Minnesota was a particularly good choice to head this workshop since she has overseen the authoring of many of the biological and health science resources available at the University of Minnesota. On EDUNET, available CAI in health sciences ranges from undergraduate through pre-professional and graduate to professional school level. Four institutions—Dartmouth, Notre Dame, Minnesota, and Wisconsin—offer biological and health science resources over EDUNET.

Dartmouth has several programs in the area of general health

awareness. One such program is ELECTRO, a program used for the diagnosis of acid-base and electrolyte equilibrium disorders. After the user inputs data, the program outputs one or more diagnoses and a bibliography of relevant journal articles and books. Another such program is TEACH-1, which covers direct and indirect methods of determining water content in body tissue. Dartmouth also offers a host of biology programs in areas such as population dynamics, genetics, and hormones, as well as medical programs in drug classification and cardiac anatomy.

Notre Dame offers a number of biology and health science programs, including THERMO, which deals with body temperature regulation. Another program, Medical Diagnosis, allows the user to diagnose one of nine diseases when given a set of symptoms for a hypothetical patient. During the course of the program, users learn that even simple descriptions of the nine diseases are hard to remember, and that allowing the computer to remember the facts frees them to make the diagnosis.

A botany program conceptually similar to the medical diagnosis program is an identification program in taxonomy in which the user enters leaf descriptions, and, from those descriptions, identifies the plant species. It is essentially a computerized taxonomic key. Also, at the University of Notre Dame, a series of computer-assisted instructional tutorials are used in introductory biology, as well as programs in cell biology on volume and growth, and programs in ecology that deal with endangered species.

At the University of Wisconsin and at the University of Minnesota, students use Patient Simulation, a program written by Dr. Richard Friedman of the National Institute of Health, which simulates the patient-physician encounter. In fact, medical students at the University of Wisconsin are required to complete the program as a graduation requirement. The user, as doctor, can ask for over 400 tests, each at a certain cost. If a test is ordered when the lab is closed, and the results are needed immediately, the test is obviously going to cost more. The object of the program is to perform an accurate diagnosis of the ailment at a minimum cost to the patient.

The University of Minnesota offers a package of four examination programs in medical biochemistry. These programs are typically used by medical students as an excellent review prior to national medical examinations. The medical biochemistry programs cover such areas as the building blocks of life, metabolism, and biochemical nutrition. Minnesota also has four graduate-level epidemiology simulations that use tutorial text and multiple choice format. The names and settings of these simulations can be quite colorful; one, EPI LAB-2, deals with diphtheria in Providence, Rhode Island.

Minnesota also offers a program on technical terminology that allows students to learn technical medical terminology through a complete self-paced course on the computer. Other Minnesota CAI programs include work-up and diagnoses programs in pneumonia and anemia; programs in normal and abnormal lung function; and programs in nutrition, diet, and menu planning that would also be of interest to schools of home economics. For nursing schools, Minnesota has a nursing simulation program that deals with the nurse-patient encounter. From McMaster University in Canada, Minnesota offers three programs: MACPUFF, a model of the human respiratory system; MACDOPE, a program in pharmacokinetics; and MACPEE (the reader can easily guess what that one covers). Important questions raised during the health science resources workshop were: How useful is CAI in biology and medicine? What can EDUNET's role in the future of CAI in biology and health science be?

Bibliographic and Data Resources

The workshop on Bibliographic and Data Resources on Networks was led by Dr. Benjamin Speller of North Carolina Central University and Sue Dodd of the Institute for Research in the Social Sciences at the University of North Carolina at Chapel Hill. North Carolina Central University in Durham, North Carolina, recently took a survey of bibliographic search practices and found that most college libraries in the Research Triangle Park area of North Carolina do ERIC (Educational Resources

Information Center) searches more than any other kind of computer-based search. ERIC searches involve the RIE (Research in Education) and CIJE (Current Index to Journals in Education) data bases. When faculty at the North Carolina Central University School of Library Science made the decision to do ERIC searches, they found that there were two primary sources for ERIC resources: Lockheed's DIALOG System, and Wisconsin's WISE. Since the School of Library Science faculty wanted their students to do searches for both training and research, they needed a system that was inexpensive and reliable. North Carolina Central has ERIC abstracts on microfiche, so they did not need a system that prints abstracts. Rather, they needed a system that would print citations such as author, title, journal, etc. By using WISE at the University of Wisconsin, their average charge per search was \$5 compared to \$30 for using Lockheed's DIALOG System. North Carolina Central's use of Wisconsin's WISE to do ERIC searches has also been very effective academically.

Participants in this workshop also learned about some very important developmental work taking place at the Institute for Research in the Social Sciences (IRSS) of the University of North Carolina at Chapel Hill. In a special project, librarians are working to create a bibliographic data base of Machine Readable Data Files (MRDF) according to new internationally accepted cataloging codes. The project was undertaken to address long-range goals. Many educational data base resources are not fully utilized because potential users are simply unaware of their existence and accessibility. Remote access within a network environment makes possible the sharing of these educational data bases, but information must first be disseminated on the existence and availability of these educational data bases. IRSS sees bibliographic data bases of MRDF as an appropriate vehicle for disseminating this information. As of November 1978, project staff converted a test data base to an on-line interactive mode and thus have made available information on data files in the Triangle University Computation Center (TUCC), which includes Duke University, North Carolina State University, The University of North Carolina at Chapel Hill, The North

Carolina Educational Computing Service, The North Carolina Science and Technology Research Center, and the Research Triangle Institute. The project's bibliographic data base of machine-readable data files is much more than a simple bibliographic data base. Because it is multipurpose, it can be used to generate union lists or card catalogs, and it is useful to a wide audience of librarians as well as to general users.

Resources for the Analysis of Public Policy

The workshop on Computer Models for the Analysis of Public Policy was led by Donald Manson of Cornell University. EDUNET offers several resources in this area. IDIOM (Income Determination Input-Output Model) is a multiregional interactive input-output model. The package, used by policy makers and regional economists, displays regional economic impacts at the state level of federal policies in such areas as defense and welfare. The package is easy to use, extremely inexpensive (only a few dollars per run), and suitable for student use. At Cornell University, it is being used in courses in regional planning and economics. It has also been used by the Economic Development Administration (EDA), the Federal Preparedness Agency, the Federal Energy Administration, and the Charles River Associates. In addition, IDIOM is being used in graduate courses in regional economic analysis. Other software packages for analysis of public policy are UTPS (Urban Transportation Planning System), which runs in batch mode, and Metro-Apex, a gaming simulation used for laboratory and urban studies. Metro-Apex, UTPS, and IDIOM are all resident at Cornell University.

Two other packages for policy analysis are COAL-1 and FOSSIL-1, which are energy simulations for exploring long-range energy policy scenarios. Both are available over EDUNET from Dartmouth College. Finally, two additional Cornell University resources in the area of public policy analysis are the EDUCOM Financial Planning Model, a resource discussed earlier in this chapter, and the New York State Energy Model, which will be available in several months.

Table 1. North Carolina Accounts at Foreign EDUNET HOSTS

88

<i>Person</i>	<i>Place</i>	<i>EDUNET Host</i>	<i>Resource To Be Used</i>
Law School	North Carolina Central University	Minnesota	Law materials
NITA	UNC-Chapel Hill	Minnesota	Law materials
Computer Science Professor	Duke University	MIT	MULTICS
Mathematics Professor	Duke University	MIT	MULTICS (MACSYMA)
Biomedical Engineering Staff Member	Duke University	MIT	MULTICS (MACSYMA)
Law Professor	Duke University	Minnesota	Law materials
Computer Science Professor	Duke University	Wisconsin	SIMULA and other resources at MACC
Mathematics Department	North Carolina State University	Minnesota	ISCI
Mathematics Department	Salem College	Minnesota	ISCI
Mathematics Department	Salem College	MIT	MULTICS (MACSYMA)
Home Economics Professor	North Carolina Central University	Minnesota	Menu planning, muffin, other home economics resources
Computer Center	UNC-Wilmington	Stanford	SPIRES
Business Professor	Duke	Yale	MPSX
Business Professor	Duke	Dartmouth	Business and Management Science applications
Business Professor	Duke	Stanford	SPIRES and other resources
School of Library Science	North Carolina Central University	Wisconsin	WISE
Library and Departments of Psychology and Education	Campbell College	Wisconsin	WISE
Economics Professor	UNC-Chapel Hill	MIT	TROLL
Education Professor	Lenoir Rhyne College	Minnesota	Adult reading and psychology programs

EDUNET Resource Use

Table 1 outlines the North Carolina computer service accounts at foreign EDUNET hosts; that is, accounts opened by faculty members in North Carolina to use EDUNET resources at remote hosts. Although use of EDUNET resources by North Carolina faculty may not be typical of all network users, North Carolina use may give the reader an idea of the variety of use that does occur. Notice that there are no consistencies or homogeneities in the pattern of resource use outlined in Table 1. Large private universities, large public universities, small private colleges, and traditionally black colleges have all opened accounts to use EDUNET resources. A similar variety of resources is evident. No one resource or type of resource is being used very heavily. Resources range from law CAI through tutorials in mathematics, materials in home economics, programs in business, and bibliographic data base searching, to software in econometrics. The uses to which these resources are being put span the spectrum as well. Some people are using these resources for basic research, while others are using materials for instructional purposes. Examining the level of sophistication of users, one again finds great diversity. Some users are extremely sophisticated, while others are totally naive. Some of the totally unsophisticated users have never before used a computer resource. The reason those unsophisticated users have opened EDUNET accounts is simple; the resources they are using are unique and unavailable anywhere except the EDUNET supplier institution.

In conclusion, resources suited to user needs are the essence of EDUNET. EDUNET offers a vast array of resources, and there is something available for everyone. The sample of North Carolina users is limited but, nonetheless, indicative of the potential for EDUNET usage in the future.